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MECHANICAL ENGINEERING

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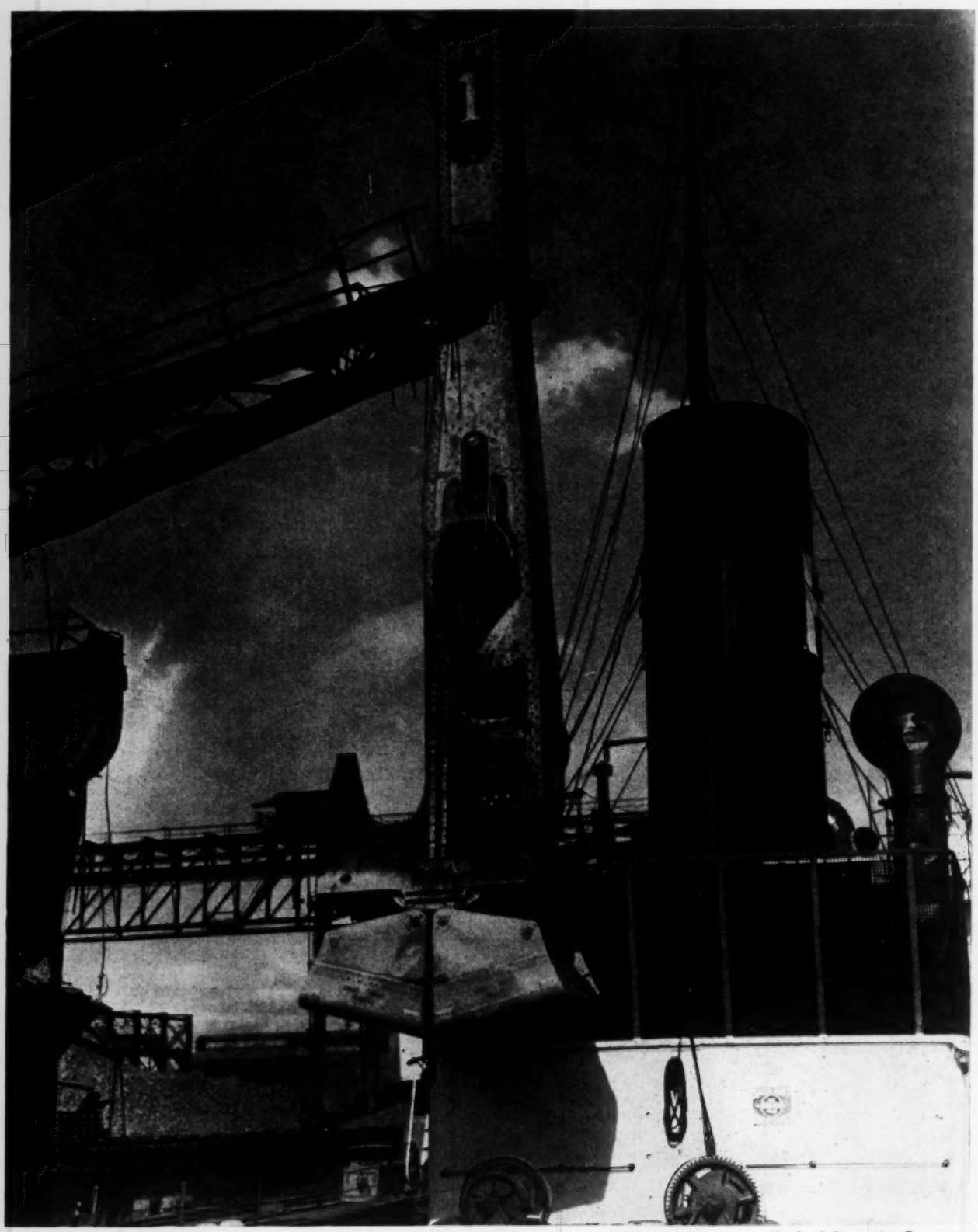

Cleveland Convention Bureau

Unloading Ore at Cleveland for War Production

(*For announcement of the 1942 A.S.M.E. Semi-Annual Meeting, Hotel Statler, Cleveland, Ohio, June 8–10, see pages 404–406.*)

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No. 5

MECHANICAL ENGINEERING

MAY
1942

GEORGE A. STETSON, *Editor*

Man Power

FIVE months after Pearl Harbor the American people are beginning to learn what war production means. They are finding out how the all-out effort demanded by modern warfare affects them personally. Each in his own terms is estimating the significance of 60,000 airplanes, 45,000 tanks, 20,000 antiaircraft guns, and 8,000,000 tons of shipping, expenditures of unbelievable amounts of money for these and other equipment, and the training of an enormous army and its supporting services. All are becoming conscious of the sources and relative importance of raw materials, of the interdependence of the several phases of our economy, of the essential balances which, once upset, have widespread consequences, of transportation and transit as facilities which are vital to the individual and the nation. And what seems most fantastic and personal of all, they discover that the economy of abundance has shifted almost overnight to an economy of scarcity, and free enterprise and a natural price system have become subject to increasing rigidity of control. With the largest national income ever paid out, opportunities for spending money are shrinking rapidly. The gratification of desires, long anticipated and long overdue, must be postponed. Sacrifice is the order of the day. The land of plenty must submit to conservation, to the salvage of waste materials, and to the use of substitutes. Habits suffer abrupt changes.

All these things are just the beginning. The intensity of their effects, just being felt, will continue to increase. The personal human tragedies that have blighted but few homes and lives to date will spread more widely before war ceases in ultimate victory. When that day comes and we look around us to take stock of our position, few there will be who will find themselves in familiar surroundings engaged in familiar tasks. Modern war plows a deep furrow in a broad field. It will be not only the men in the armed forces who will find themselves adrift when they are released for return to civilian life but practically the entire nation. For the demands of man power are reaching deeper every day to uproot us all from accustomed tasks.

Shortages of raw materials and the need for conservation, salvage, and substitution appear early in wartime. Shortages of production capacity and the demand for conversion from peacetime to wartime economy follow as the task of equipping the armed forces swings into its stride. Shortages of man power and readjustment to the demands of the program come as production rises to its peak. Today we are entering that phase in which the problem of man power must be of acute concern. If wisdom and willing co-operation are to prevail, we shall be spared the abhorrent necessity of compulsion that otherwise we must face. Each one must assess his talents honestly with the determination of serving the common objective first and his own convenience as a secondary consideration. Otherwise we must expect the decisions to be made by others to the loss of self-respect and ultimate satisfaction. Few can evade participation in this war.

How steadily we are progressing toward this almost complete participation can be sensed in the march of events, and a little concentration on the growing importance of man power may partially explain the apparently preferential treatment of labor. There is the stern fact of conversion of industry which has been violently accelerated by withholding the materials necessary for manufacture from durable-goods, non-essential industries. There is the evidence that this conversion has resulted in less temporary unemployment than anyone imagined would be experienced. There is the overwhelming need for men for the armed forces which has only just begun to be felt and which will demand a greater drain on man power when the offensive necessary for victory is begun. There are the well-known shortages of supervisory and skilled personnel and the desperate haste to train unskilled workers for simple repetitive tasks easily learned. There is the drift into industry, from home and farm, and the growing number of women workers.

There is significance in the request of the President that more older men and women be employed, in the registration of men from the ages of 44 to 65, and in the recent announcement that these men, as well as those previously registered, will be required to fill out questionnaires relating to their skills and experience. Already there has been talk of the registration of women. We face, indeed, the probability that deferment of young men who are physically fit but in essential war work will be harder to justify. Their places will be taken by older men, unfit for military service, and by women. There is significance also in the possibility faced by non-essential industrial plants that instead of being able to retain their supervisory and skilled personnel under conditions that necessitate production at low rates of capacity, economic factors will force the employment of these staffs and plants in war production. The task of supplying the market for luxury goods may have to be left to a few plants that can operate at high capacity.

One gets the strong hint from these indications that

opportunity is being afforded to get into the production of essentials before the stage of compulsion shall be reached.

Since Pearl Harbor we have traveled far along the road of all-out united effort. We have done it to date in the democratic way of voluntary co-operation. As the program advances we shall do well to assess the need for man power in greater rather than lesser terms and act accordingly—voluntarily still—and thereby avoid a too-obvious compulsion.

Commencement 1942

IN MANY colleges Commencement 1942 will anticipate by several weeks the dates announced in calendars set up before Pearl Harbor. Customs change slowly. Institutions that grew old under Colonial governments, that survived the Revolution and the War Between the States, that sent its sons forth from classroom to battlefield in every war from local skirmishes with the Indians to the first World War, are sending them again today to join the armed forces or to take their places in the industries and laboratories and services that support those forces. Once more, as happened a quarter of a century ago, the academic routine is interrupted in the face of the nation's great need, this time to make full use throughout the year of their faculties and educational plant for the winning of the war. And this time, as twenty-five years ago, thousands of young men are coming to decisions of duty and sacrifice that will affect the remainder of their lives. Commencement 1942 appears to have a very special significance indeed.

Whoever christened the closing exercises of undergraduate life "commencement" did so wisely and with vision. Usage would have robbed the term of its literal meaning were it not for the orators who, year after year, have called our minds back to the fact that on this occasion young men take on the serious responsibilities of manhood, of building a career, earning of a livelihood, of founding a home and family, and of serving a community. There are also the nostalgic and sentimental ones who pronounce a valediction over the happy and carefree days of undergraduate life as though it were something that might be caught in full career and maintained brilliant, hopeful, healthful, and permanently immature—life at its best and brightest when life itself is barely begun. Yet neither point of view reflects the true significance—that forever "What's past is prologue" and tomorrow always begins today. Beginnings and endings alike—even birth and death—are swallowed up in the forward urge of life and time.

It would be a happy relief to most of us if the hard decisions of epochal times could be made for us. Indeed, in a sense, perhaps they are, even when an apparently voluntary choice is dictated by an inner urge that cannot be denied. But such is not the lot of free men. It is the privilege of making that choice for which we are fighting, knowing that if we fail to avail ourselves of it, compulsion follows.

Commencement 1942 offers a hard choice for young men vital with hope and ambition. To foreswear what appeared to be a heritage of comfort and security for the hardships and uncertainties of a world torn with a war they did not initiate is a grievous burden. But so also is it for their fathers who faced up to a similar situation twenty-five years ago, who endured a devastating depression, and who looked forward to enjoyment of the fruits of righteousness and industry. So also is it for their grandfathers who sacrificed sons and assumed their burdens and who now feel the weariness of old King Charlemagne at Roncevaux, called back once more to the battlefield.

Only in degree does Commencement 1942 differ from others. For each of us the instant present is the opportunity to erase with praise and glory in some unborn tomorrow the shame and folly of a dead yesterday. War delays hope, betrays imagined security, tries faith and courage, unbalances conviction, but so do the inevitable changes of times of peace. War is a violent and accelerated phase of change. It throws values into high relief and subordinates things. Commencement 1942 is not for young men alone; it is for the entire world and all the people. "Youth shows but half; trust God: see all, nor be afraid!"

Alex Dow

ALEX DOW was one of those strongly individualistic figures that make a vivid impression on first meeting. His appearance—the loosely fitting clothes, soft collar, white tie—the characteristic posture of the body, the way in which he held his head and hands—his little mannerisms, burred speech, keen wit, pithy phrases, a flare for quotation—all these combined to invest him with a vigorous and long-remembered personality. They were outward evidences of inner qualities that were happily combined in proper balance. He had the spirit and lived the life of a pioneer. But it was not that pioneer spirit which forces men to strike out into the wilderness because they cannot live with their fellow men or because the encroachment of civilization restricts their independence of thought and action. It partook more of the pioneering spirit of the scientist, the engineer, and the businessman. It was not the lone-wolf spirit of the pioneer who cannot face up to human contacts, competition, and institutions. It was a progressive spirit with vision and an acute understanding of the complexity of human beings and human institutions which the typical pioneer seems seeking to avoid. If his methods and his results were distinctive it was not so much because he had a stubborn desire to be different as it was because he possessed a talent for studying and appraising his own problem in its many phases, for thinking ahead not only about his own job but also about its relation to the trends of the times and the environment in which it was placed, that made them so. The rare combination of engineering, business, and social instincts that made him a successful, brilliant, and progressive public-utility executive, made him also a citizen of a high order.

The MECHANICAL ENGINEER *in* WAR

By BRIG. GEN. EARL McFARLAND

ASSISTANT TO THE CHIEF OF ORDNANCE, U. S. ARMY

WE ARE now in this war. We are all in it all the way. Every single man, woman, and child is a partner in the most tremendous undertaking of our American history. We must share together the bad news and the good news, the defeats and the victories—the changing fortunes of war."

This quotation from the President's address to the nation, of December 9, is the keynote of my remarks to you tonight. We entered this war December 8 and from that moment, through the present, until that day when victory shall have crowned our united effort, those words must be the guiding principle of every one of us—professional man and layman as well. Knowing The American Society of Mechanical Engineers as I do, the President's words are, in a special way, the guiding star of the effort of the A.S.M.E. now and for the future.

BRIG. GEN. EARL MCFARLAND

May I, at the start, pay tribute to the work of your Society as a force in the betterment of the American standard of living in time of peace and as an equally potent force in the American standard of fighting in time of war. Those of us of the Army who, through the years, have been in close contact with the work of your great organization can testify in abundant measure to its value to the American people no less in the pursuits of war than in those of peace.

And may I in a special way salute the members and guests of the Society who can claim the great State of Texas and the neighboring states here in the Southwest either as home or as the place of professional activity. This city and this state exemplify the widening influence of modern war in its dependence upon the mineral, industrial, and agricultural forces of the whole nation. Modern war is no longer a question of guarded seacoasts and small armies. It is decidedly a problem of using all of our strength for one purpose. Now the strength of Texas in all of its various fields is being applied with a will. With such strength of man power, mineral power, and machine power, combined with that of forty-seven other states, there is no doubt in my mind, and there can be no doubt as to the final outcome of our present war effort.

I have chosen to speak to you tonight on a somewhat general subject, "The Mechanical Engineer in War." As you may know, I am assistant to the chief of the Ordnance Department of the Army of the United States. Ordnance is the one military field where the mechanical engineer has his greatest activity. Therefore, what I shall have to say tonight is entirely from the Ordnance viewpoint; and when I speak of the engineer in war I remove him from his place as a civil, metallurgical, or mining engineer and concentrate upon his vitally important share in the design, production, and supply of our military armament. Guns, ammunition, fighting tanks, bombs, and all the myriad appliances that we now know as modern armament are embraced within the term "ordnance;" and ordnance depends primarily upon mechanical engineering.

The mechanical engineer plays a vital role in ordnance engineering design. I can best illustrate this point by outlining briefly the scope of our engineering design problem. During the last year approximately 145 new items of ordnance have been built, tested, and standardized through the joint activities of the Ordnance Department and American industry. In our service a new weapon is not adopted as standard for the Army until it has been tested under field conditions by the soldiers who will use it. Until the new arm has been found tactically superior to the former weapon by fulfilling some new tactical use, the new design is not adopted. Modern warfare is not static. Consequently the need for new weapons and new engineering designs is ever present. It follows that the mechanical engineer thus has a continuing responsibility. It is he who in the ordinary operations of American industry must lend his co-operative efforts to the Ordnance Department in the solution of its many problems. This he has done unfailingly

An address delivered at the Spring Meeting, Houston, Texas, Mar. 23–25, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

through the years. It is he as an inventor who, through the National Inventors' Council, must submit the new ideas for engineering design in order that that group of scientists and engineers can separate the urgent from the less urgent and utilize those devices which have immediate application to the winning of the war. The National Inventors' Council, headed by C. F. Kettering of General Motors, has been in existence for some time more than a year, has examined 41,000 inventions and inventive ideas—many of interest to the armed services—and is hopeful that some outstanding and phenomenal military invention may result from its encouragement and advice. Throughout the entire process of standardizing a new weapon, it is the mechanical engineer who must guide that lengthy but necessary route of mock-up in the design room, of construction of pilot in the factory, of mechanical tests at the proving ground, of service tests in the field, of production tests in the plant, so that the completed design represents the very best headwork all along the line. It is a maxim in our service, and has been from the beginning, that the weapons with which the American fighter is armed must not only be the equal but must be superior to those of any possible enemy anywhere.

GARAND RIFLE A SUPERIOR WEAPON

That this high objective is constantly met I can best indicate, I believe, by citing to you the testimony of that greatest of present-day American soldiers, General Douglas MacArthur, who after leading his men against such tremendous odds and against such a perfidious foe in the Philippines, has now been assigned to even greater fields of leadership and responsibility. Within the last few weeks, from the very battle front of Bataan, General MacArthur radioed to General Wesson, my chief, who heads the Ordnance Department of the Army, a report that the Garand semiautomatic rifle had proved itself a superior weapon under the inexorable demands of battle in the shell holes of the tropics. Many of you are familiar with the controversy which raged around the Garand rifle as a suitable weapon for the American soldier. The Garand is a semiautomatic shoulder rifle which increases the firepower of the individual man nearly three times over the soldier equipped with the bolt-action piece. The Ordnance Department had worked at the standardization of the Garand rifle for many, many years. When it was finally adopted six years ago, there was much discussion as to its true worth. But we of the Ordnance Department held our ground because we were convinced of the superiority of this new weapon. General MacArthur's testimony proves the point beyond a doubt. When General MacArthur's report came through, one of the first to congratulate the Ordnance Department on its magnificent achievement was the Honorable Robert P. Patterson, Under Secretary of War. In a letter to General Wesson commenting upon General MacArthur's report, Judge Patterson said, "Your strong and steady support of the rifle has been amply vindicated by its performance in battle....I think that the critics will now sing low."

Not in the design of major items alone can equipment remain static. Changes must occur; damnable and irritating as they are, they *must* occur. Changes are dictated by the necessity of always having equipment superior to the enemy's—the muzzle velocity of a shell may have to be increased to defeat the enemy's new tank armor. The gun and ammunition have been designed on one basis and production is under way. A major operation is required to make the change. But is has to be made. Changes are unpredictable but certain and point to a constant progress in military effectiveness. These changes for progress must be encouraged and accepted, not resisted.

The mechanical engineer in ordnance production has yet another vitally important role to fill. In our arsenals in time of peace he is the person who must keep alive the art and skill of arms production. He must determine the precision of workmanship demanded and insist that the required standard of tolerances be never relaxed. In time of war he is the person throughout industry who must make sure that the "arsenal of democracy" turns out its equipment in the tremendous volume required without the loss of a single operation and without the waste of a single minute.

How well he is doing this today some ordnance figures will show more conclusively than I might attempt by elaborate discourse. Let me quote a few of them for you.

In the vast field of ordnance inspection—we now have nearly 15,000 civilian ordnance inspectors throughout the country—for one month 7687 prime contracts and 40,039 subcontracts were inspected in order that every phase of ordnance production might meet the drawings and specifications. Mass production has recently been attained in the manufacture of two new major weapons—the 105-mm howitzer and the 20-mm aircraft cannon. Shell loading increased by 200 per cent in one recent month over the preceding month, while during the first three weeks of January last the production of 0.30-caliber ball ammunition was doubled as compared with the preceding month. Material is rolling!

Possibly a more significant presentation of the case might be given by referring to the production job in terms of money. Allocations by the Ordnance Department averaged recently $717.42 a second on the basis of an eight-hour day. Over a given five-week period the daily expenditure averaged $20,660,000. This is expenditure and therefore represents Ordnance munitions *received*. Already Ordnance appropriations total five billion dollars more than those for the entire period of the first World War when $7,500,000,000 was appropriated for the fiscal years 1917, 1918, 1919.

MAINTENANCE OF MECHANIZED EQUIPMENT ESSENTIAL

But for all our success in the design and production of ordnance equipment, the job is not complete until that equipment is delivered to the fighting men in fighting condition and unless it is maintained in fighting condition throughout twenty-four hours of every day until victory is reached. Upon the Ordnance Department rests the grave responsibility of maintaining and servicing all of the fighting equipment in the field. You men of industry know what a great responsibility it is to service any peacetime mechanical products which are used in quantity. The Ordnance responsibility involves all the maintenance and spare-parts business of a large automobile-manufacturing industry. It involves the maintenance and servicing of all weapons. It embraces the huge warehouses of supplies for combat vehicles, for guns, for aircraft armament and bombs, so that the fast-consumed needs of material and ammunition are constantly met. To this end the Ordnance Department operates one of the greatest service systems the world over. Its soldiers are stationed with nearly every fighting unit. Its engineers and technicians are to be found wherever fighting planes are flying. Its servicemen are on every battle front. Its warehouses and depots must be located near and constantly ready wherever American fighting men have a job to do. All this means not only vast supplies of equipment but it means thousands and thousands of trained men. In the Ordnance organization today aside from the hundreds of thousands of civilians in the arsenals and private factories throughout the land, we have thousands of soldiers and officers who are especially trained for these maintenance and supply functions. At the Aberdeen Proving Ground in Maryland we have the huge Ordnance Training Center where enlisted men, noncommissioned officers, and commissioned officers are trained by the thousands in the complicated processes of keeping our guns firing.

What may the mechanical engineer in this year 1942 conclude

from this hasty résumé of my estimate of his place in modern war?

I think he can agree with me that our military practice in the design, production, and supply of military equipment to our soldiers is sound and successful. Time is always the irreplaceable factor in war, and unfortunately time is required for a military organization to swing into the tempo required for modern battle. I can assure you that American military armament has been planned along the soundest lines and that today in every phase of its design, production, and supply it is undergoing revision and improvement to attain the very highest degree of suitability for today's warfare. In addition, we in America have an industrial strength which is second to none the world over. On design and production, modern military operations depend.

But most important of all factors at the moment, and greater than any I have yet spoken of, is the will to win. Unless we are determined, our effort lacks half its energy and our results may be half as great as are required for victory. What I am saying was said by Napoleon, in a simple phrase and one more striking than I might coin. He said, "In battle, the morale is to the material as three is to one." Translated into the vernacular, that simply means that no matter how great our material strength, our determination to win is three times more important. How will that determination be brought about? This is a field somewhat beyond the mechanical engineer and the Ordnance officer, but I venture to state a belief which I hold to be basic to success: Our people must still develop a sense of righteous anger against a contemptible enemy whose actions deserve the sternest treatment. Until we know what it means to have a total hate for an unremitting foe and until we are willing to discipline ourselves and sacrifice our strength in order that we may inflict the greatest of damage upon such an enemy, our fighting forces and our material strength will not speak the kind of language a ruthless fighter understands. For, ladies and gentlemen, make no mistake about it, we are face to face with as ruthless an enemy as the world has ever known. Until we are ready to meet that kind of fighting with the intense hatred it deserves, we will never be able to reach the goal for which we are striving.

I wish it were possible for me to conclude my remarks on a more kindly note. But we are at war, the worst war the world has ever known. We will not win it by a lackadaisical attitude in the factory, on the farm, or anywhere else. We must realize that we have a job to do—the greatest job in the history of the world. And until we get *mad* about it and fight with a hatred as deep as our enemies' cunning and ruthlessness, we can not exert our full strength. The day has come to match our engineering power with the will to fight—to fight hard at all costs—and to win.

Ewing Gallaway

FLAME-HARDENING TURRET RINGS FOR THE MEDIUM TANK

(A session on flame-hardening will be held at the 1942 A.S.M.E. Semi-Annual Meeting, Hotel Statler, Cleveland, Ohio, June 8–10. See pages 404–406 for announcement of meeting.)

The PHILOSOPHY *of* ENGINEERING EDUCATION

By R. L. SACKETT

DEAN-EMERITUS, THE PENNSYLVANIA STATE COLLEGE

PHILOSOPHY is defined as "the science which investigates the most general facts and principles of reality and of human nature and conduct; . . . the science which comprises logic, ethics, aesthetics, metaphysics, and the theory of knowledge."

Engineering education includes that sector of knowledge which began with natural philosophy—mathematics, astronomy, chemistry, geology, and the laws to which the materials and forces of nature conform. It therefore comprises important "general facts and principles of reality." It also contains the most rigorous logic in both its theory and its applications.

It was not until the development of the power industry that the training of men in manual and technical skills became a part of systems of education. The traditions of apprentice training and guild control transmitted certain features to the mechanic arts and it was only as science developed new industries and as different functions became recognized that engineering education emerged between the traditions of classical education on the one hand and manual arts on the other. Its evolution and gradual assumption of a place in education were slow and it was only grudgingly accepted for many years.

The fact that technical education recognized the need for skill and still does, though the emphasis has changed, was particularly discredited. Anything material, realistic, and scientific was outside the pale of learning to the classicist, and the remnants of that attitude still prejudice the minds of some who emphasize the value of learning for its own sake as against those who are motivated by the applications of knowledge to the problem of living.

Both systems stem from books, lectures, thought, and the experience of leaders. Both believe that "they also serve." Which system is vital to the continuance or revival of our civilization is of small matter if neither survives. To help society to save its own soul is important and to enrich it further, if it is resuscitated, is elemental.

ENGINEERING

The earliest definition of engineering was embodied in the charter of The Institution of Civil Engineers of Great Britain over a century ago. It is attributed to the English highway engineer, Tredgold, and reads as follows:

> Civil Engineering is the art of directing great sources of power in nature for the use and convenience of man, being that practical application of the most important principles of natural philosophy which has, in considerable degree, realized the anticipation of Bacon, and changed the aspect and state of affairs of the whole world. . . . . The real extent to which it may be applied is limited only by the progress of science; its scope and utility will be increased with every discovery of philosophy and its resources with every invention of physical and chemical art, and equally so must be the researches of its professors.

From these early definitions it is clear that more than one hundred years ago engineers recognized the broad human import of their works.

While "human nature and conduct" became a factor in engineering from the beginning, the relations of workers to masters were simple until the industrial revolution introduced complications. The study of human nature and conduct became important, but the very different purposes behind such study, at that time, are illustrated by the attitudes of the essayist and the engineer.

Emerson's essays or his journal represent one point of view and engineering thought put into canals, boats, buildings, bridges, railways, and industries represents another. There is little to be gained by dwelling on the differences. What is there in common that should be emphasized?

Both philosophies attempt to prepare their novitiates to live more fully—healthfully, usefully, and thoughtfully. Both advocate the finer, freer, socially-minded life. Is it too partial to say that the academic pursues a line of thought based on precedent and the scientific a line of action based on experiment? The essence of effectiveness in planning for a democratic way of life depends on the possession and use of vision, ingenuity, and social consciousness in utilizing natural and human resources for the common good.

The motivation which energized engineering education differed from that which sustained arts education. One was characterized by motives which stemmed from human action and the other from historical precedent and speculation on human trends, influences, and objectives.

Science was the mainspring of engineering education and a relatively late interest of arts education. The applications of the scientific method to liberal education have made slow progress. In the first place its procedure is the antithesis of the ruminative or speculative philosophy which had stimulated classical education. In the second place it was contended that in dealing with man and his unstable emotions it was quite impossible to apply the scientific method to the analysis of human behavior. The difficulties are to some extent those which ignorance always raises in its own defense. We have several thousand years of contemplation of man by man. It constitutes our literature. We have only a century of factual study of man designed to probe, define, and analyze his reactions to simple situations. It appears to have been demonstrated that there are predictable reactions of human beings to specified conditions. One of the most interesting cases is the survey of public opinion. Patterns of human behavior can be roughly measured. Science is influencing social evolution by developing methods of measuring individual abilities, motives, aims.

HUMANISTIC-SOCIAL STUDIES

The evolution of arts education toward goals of utility has been evident throughout the century. Engineering education has always maintained a stem of general education with some emphasis on useful applications. The most recent pronouncement is contained in a report[1] which was issued in 1940 by the Committee on Aims and Scope of Engineering Curricula to

Address of the retiring vice-president of Section M (Engineering), A.A.A.S., Dallas, Texas, Dec. 31, 1942.

[1] Published in MECHANICAL ENGINEERING, October, 1940, pp. 727-730 under the title, "Whither Engineering Education?"

the Society for the Promotion of Engineering Education.

This report recognized a trend and a need for emphasis on a broader base for preparation to enter the engineering fraternity, of which the nucleus is the engineering profession. It also recognized the wide distribution of graduates in functions and positions having social significance.

> We believe that there are advantages in the parallel development of the *scientific-technological* and the *humanistic-social* sequences of engineering education. When the elements of these sequences are compartmentalized and taught at different stages of the curriculum, they frequently remain unrelated and un-co-ordinated in the student's mind. Furthermore a continuous development of the humanistic-social sequence prevents its complete relegation to the less mature stages when it cannot be so effectively presented.

This recognition of a trend and a responsibility for accomplishing this purpose in humanizing engineering education is justification for the discussion of psychological, economic, and social subjects.

PSYCHOLOGY

Psychology is using the scientific method to make a "stress analysis" of that most complicated structure, the human mind. Engineering education has been alert to the significance of the result of the analysis of human qualities, because it is a part of the foundation of progressive industry and of modern personnel systems. First comes the analysis of the job; second, the specification of the skills, physical habits, and temperament of the desirable employee; third, the measurement of such skills, habits, and reactions of applicants; and fourth, the analysis of results to measure the effectiveness of tests used as a means of better selection.

The primary interest of the classicist was in history, ethics, and religion. The primary interest of science was in man's environment and its effects upon beliefs, manners, and morals. Science combated certain fears, superstitions, and a spirit of intolerance. Ignorance of physical laws has profoundly affected human behavior and continues to hobble human progress.

In the applications of psychology to industry, advances of considerable moment have been made, notably by such studies as those of the Western Electric Company and others. The investigations which industry has made of the relation of personal traits and of working and social conditions to efficient behavior have advanced the study of habits, mental troubles, skill, and adjustment to working conditions (or the provision of working conditions conducive to efficient and satisfying work).

The psychologist is carrying on an extensive experimentation to find tests which predict engineering abilities in distinction to nonscientific interests and aptitudes. This is a subject of moment for its own sake and also it has an important bearing on guidance, admission, and the practice of transferring students from one curriculum to another, especially nonengineering and technical curricula.

The value of tests of mathematical comprehension, of science, and of English have long been accepted. Scholastic aptitude tests are used by a number of institutions in admitting students. The results are also an aid in counseling. They supplement the high-school diploma and high-school records in establishing fitness to enter college and they assist in correct placement within a college or university.

There is a definite move toward the study of the individual and an evaluation of his assets as a college student. This is in contrast to mass admission methods. Individuality is being recognized by the addition of the interview to the usual admission requirements when considering fitness for higher education.

The psychological study of the acquisition of skills began with the telegrapher and the typist, to which engineer Frank Gilbreth contributed, and has continued into more and more complex abilities such as mechanical aptitudes, for which we have a number of tests.

The exploration of personal ability has been pursued with increasing interest and effectiveness in education until now a wide variety of tests are given to grade-school, high-school, and college students to expose personal differences in accomplishment, trends in interest and in mastery of subjects, and causes of defects, and to test the effectiveness of teaching methods.

The engineering educator is participating actively in the exploration of tests and their validity. He is eager to help the psychologist, to be convinced of the soundness of new probes of ability, and to use them cautiously. He is skeptical of unproved instruments and weary or wary of involved techniques.

INDIVIDUALITY

Personnel studies in industry are concerned with discovering individual human capacities, complexes, and mental and physical habits. They are designed to help the individual to find the type of job which fits best his strength, speed, skill, or mental attitude toward routine work or diversity. Education, interest, and ambition are factors in human adjustment.

Gradually, a level is approached where tests have not yet been verified by sufficient experience and where correlations between test scores and performance are not yet stable and valid. The more complex the abilities required, the more difficult it is to design tests to discover them. Where one quality only is to be measured and others can be eliminated the results are more reliable. Where many factors are involved their interplay may be greater and the results more baffling to analyze.

PERSONAL DIFFERENCES

The evaluation of personality is the most evasive, perhaps volatile, subject which psychology can attack. Attempts to inventory personality are as old as the race, but until recently it was measured by hunches, impressions, and more or less superficial reactions of one individuality to another.

Systematic attack is being made, and out of a continued and co-operative effort, progress is being made which will lead to better knowledge of effective techniques and also to an understanding of the limitations of such methods in unraveling the complicated patterns into which our interests, abilities, and emotions are woven.

PERSONALITY AND PLACEMENT

In engineering colleges there is a definite trend to

1 Provide information on engineering and on self-analysis by which to discover the fitness of the individual for a field.

2 Orient the admitted student to his job.

3 Describe the nature of the college discipline and its relation to probable experience.

4 Emphasize the personal qualities necessary to advancement in industry.

5 Introduce the student to industry and what it expects of the graduate.

6 Assist him in studying himself and industry in order to select that function which seems to be his forte.

7 Encourage the junior graduate engineer to take a personal inventory of himself and his job every few years when he is discouraged or proposes to change the nature of his work.

This process of individualizing and socializing education has only begun. Industry, likewise, is only at the first mile in studying personal differences and the selection of men for satisfying work. Thus there are grounds for encouraging the psychologist to continue the application of scientific tools to those human problems of concern to engineering.

SOCIOLOGY

The sociologist can also co-operate with the engineer in certain areas to clarify trends and study methods of improvement of human relations in and around industry.

The instability of emotional reactions is no excuse for not applying the scientific method, so far as it can be applied to the most complex human problems. The detection of emotional balance or unbalance is in itself important. To discover causes may be an art. In any event there is opportunity for art, science, psychology, and sociology to work with engineers in the discovery of causes of maladjustments and their cure. There is room for arts education and engineering to join in further mass attacks on the most crucial problems of social welfare, the human being, and his environment.

In a valuable pamphlet,[2] "Present Status and Trends of Engineering Education in the United States," D. C. Jackson discusses the changes taking place and likely to take place in the study of the humanities in engineering colleges. He says:

> Attitudes expressed within engineering circles toward the importance of economics and sociology (which will here be jointly called political economy) as subjects for close and accurate study by engineering students, have changed tremendously in the emphasis put on the words "importance," "close," and "accurate." But faculties have been slow in conceiving measures for accomplishing the purpose. It probably is a fact that engineering faculties now generally agree on a need to dovetail engineering into political ecomomy so that engineering and political economy may directly and soundly influence each other, as has been done so well with engineering and the physical sciences, but the means for accomplishing this aim have not been set up. Many attacks on special aspects of the problem are carried on with interest and apparent success, but no vigorous attack on the fundamental core of the joint problem has been provided as yet; and little in the way of funds has been made available to support such a fundamental attack.

In another address[3] the author of the paragraph just quoted said: "Let me emphasize the fact that engineering is the tie which bridges the chasm lying between the mathematical, physical, and biological sciences as one abutment and the human phenomena of economics and sociology, with their psychological qualities, and which jointly constitute political economy, as the other abutment."

Sociology is the science of the origin and evolution of society, or of the forms, institutions, and functions of human groups. Comte coined the word "sociologie" in 1838 to designate the comprehensive objective study of the associated life of man. In contradistinction to psychology which is the study of individual attributes and habits, sociology is concerned more with learning how the other half lives, with trends in education, housing, family life, industrial environment, political, religious, and social movements which influence living.

In this discussion we are concerned with the impact of industry on living conditions, on homemaking, education, religion, the state, the use of leisure, and moral as well as physical standards of living.

Neither the census nor other statistics gathered by the various units of government yield information of value to sociology except by inference or by revealing broad trends. The majority of social studies have been the product of societies and of graduate students and teachers. Correlated studies of industrial-social conditions are rare; the majority are of conditions in one industry here and another there.

The census tells us that there has been a drift from rural communities to the marginal areas of large cities rather than to the metropolitan area itself. White-collar classes have created new problems by removing to suburban areas, adding to the demand for better transportation, education, housing, and recreation.[4]

The U. S. Department of Agriculture has developed a science of crop prediction which is depended on by growers, millers, and investors generally. There is no comparable attempt to evaluate industrial trends and predict future markets. Craft and apprentice training or education cannot prepare men for a transfer from one industry to another or from one skill to a different one when future needs are unknown. The absence of scientific study of consumer demands and production schedules leads to unemployment. The shift of demand for goods follows certain patterns, the laws of which have not yet been discovered and there are finger boards which indicate drifts toward a destiny which needs study desperately if we are to avoid social-industrial rocks on which our present form of civilization may be wrecked.

ECONOMICS

Wesley Mitchell, distinguished economist, in his presidential address to the A.A.A.S. in December, 1939, spoke on "The Public Relations of Science." He said, "The fate of free societies hangs upon the wisdom or folly of mass decisions. The gravest dangers to democracy come from within, not from without. They are ignorance and propaganda that turns ignorance to its uses. The best way of dispelling ignorance is by diffusing knowledge . . . . . John Dewey is warranted in saying that 'the future of democracy is allied with the spread of the scientific attitude.' "[5]

Sir Francis Bacon urged the application of the scientific method to the study of human affairs. Despite this early recognition of the need for factual knowledge about man, the physical sciences advanced more rapidly and penetratingly than the social sciences. Physiology is an example of magnificent advance. The chemistry and physics of fatigue have yielded values not only in the fields of medicine but also to industrial management.

Economics with all its disagreements by experts shows signs of applying scientific analysis to its solution of problems which involve the same elusive factors of human vagaries, emotions, and demands.

Academic traditions, adherence to theories, and disregard of the crying need for economic guidance have led engineering teachers to attempt to bridge the gap between economic speculation and practical instruction. The engineer is a fundamentalist in economic theory; from the welter of controversy he is resorting to basic ideas and on them he is building a simple structure of economic practice. Scientific principles can be applied to the solution of the pressing problems of demand, supply, production, and economic management. The quality of recent books by engineers on industrial economy is notable.

It remains for the economist to apply analysis to his problems and for the engineer to attack the confusion of theories. Together these two must pool their interests in so far as they relate to the actualities of trade and look toward a joint contribution to sound principles of production, distribution, and consumption.

CONCLUSION

Engineering, in one hundred and fifty years, has advanced social well-being by conserving the forces and materials of nature and transferring physical burdens to machines which obey the principles of control discovered by science.

Research by industrial psychologists has advanced the

(*Continued on page 372*)

[2] Published by the Engineers' Council for Professional Development, 29 W. 39th St., New York, N. Y., p. 133.

[3] *Science*, Aug. 30, 1940, p. 185.

[4] Report of President's Committee on Recent Social Trends.

[5] *Science*, Dec. 29, 1939.

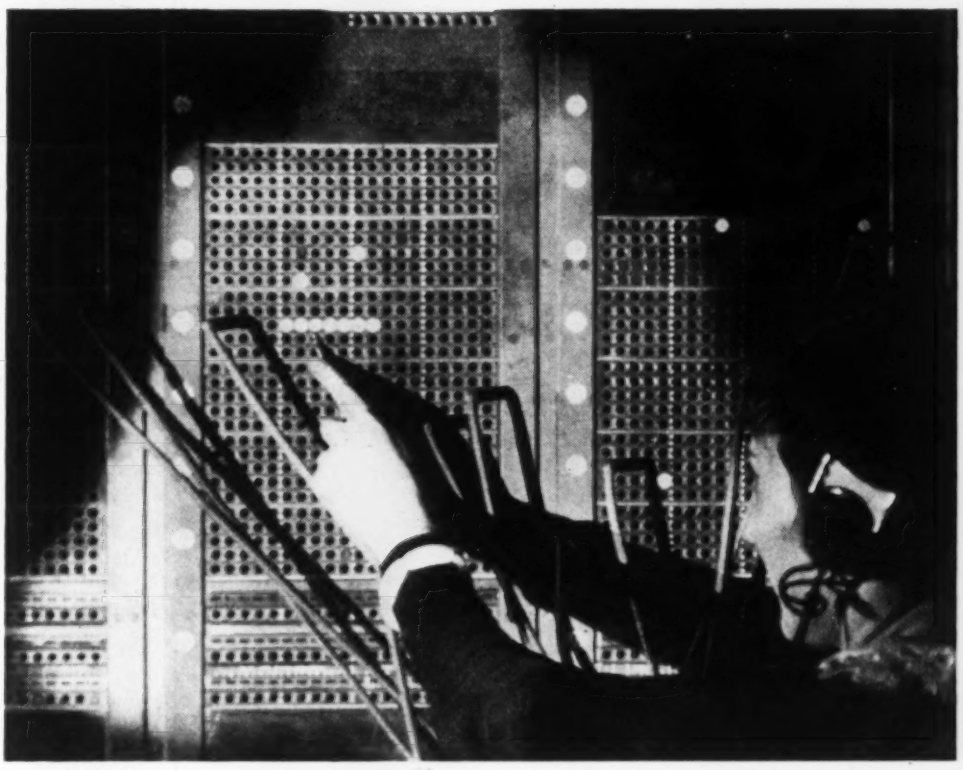

FIG. 1 OPERATOR COMPLETING CALL

Some MECHANICAL ASPECTS *of* TELEPHONE APPARATUS

Part 1—Development of Crossbar Switch as a Typical Unit of Automatic Dial Telephone System

By J. D. TEBO[1] AND H. G. MEHLHOUSE[2]

ONE half the telephones in the world are in the United States. A total of 100,000,000 calls a day are made on this equipment, on matters large and small—routine or emergency. Especially in these days of national emergency, communication facilities have become indispensable to our defense organizations, vitally assisting in speeding up the program of national safety.

Americans have grown to accept their telephones as a necessity, seldom realizing the vastness of the system and the spirit of service in the large organization constantly striving to maintain and improve a means of communication already unexcelled. Seldom is it realized that the equipment in the home or office is only a very small part of the facilities required in this business of telephoning. A network of wire literally covering the nation from coast to coast, and intricate switching devices for interconnecting the telephones throughout the nation and most of the world all combine to transmit the spoken word quickly and faithfully.

The vastness and complexity of such a service must of necessity require a wide range of equipment which in the Bell System totals 44,000 kinds of apparatus involving 170,000 different parts. Some of the mechanical aspects of such equipment will be presented in this paper, particularly those having to do with design and manufacture, jointly handled for the Bell System by the Bell Telephone Laboratories and Western Electric Company. Obviously, the entire range of telephone equipment cannot be included. It is, therefore, intended to deal with a specific telephone switching mechanism, known as the crossbar switch, which is used in the latest dial telephone system.

HISTORICAL BACKGROUND

In the early days of telephony, small switchboards accommodating a limited number of lines, manually operated, were capable of interconnecting the few telephones in service. As

[1] Bell Telephone Laboratories, New York, N. Y.
[2] Western Electric Company, Chicago, Ill.

Presented at a meeting of the Detroit Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Detroit, Mich., February 3, 1942.

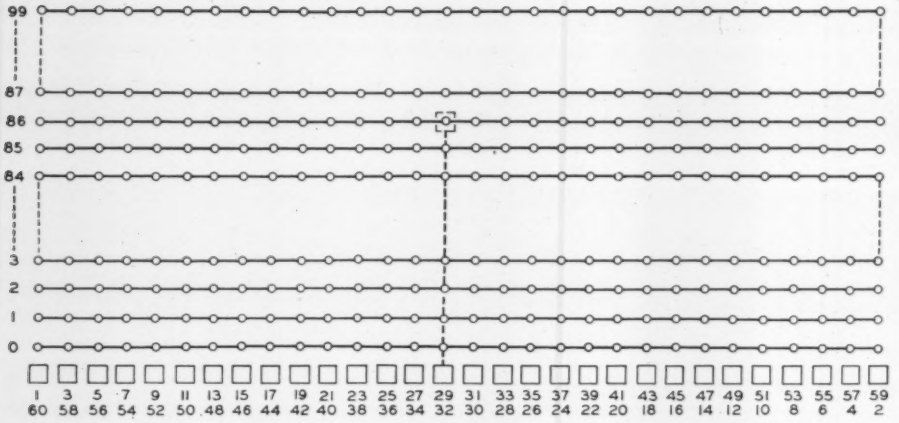

FIG. 3 THE PANEL SYSTEM SELECTS THE PROPER TERMINAL BY MEANS OF A BRUSH TRAVELING ON AN ELEVATOR ROD
(Average motion per connection, 7 in.)

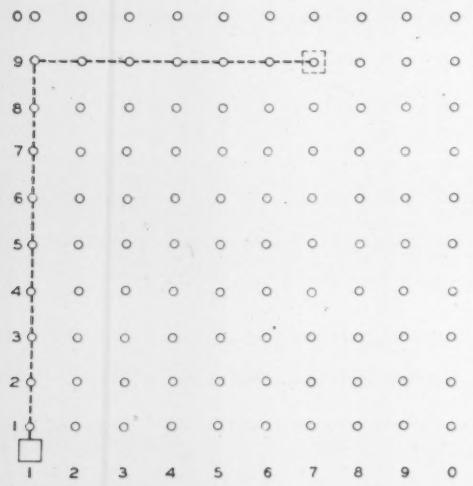

FIG. 2 THE STEP-BY-STEP SYSTEM USES 100 TERMINALS AND ONE BRUSH
(Average motion per connection 1⅞ in.)

the subscribers increased in number, it was no longer practicable or economical to have all the subscribers' lines brought to one center in a community and more and more centers became necessary. Under this condition, the trunking or interconnecting system became increasingly complex, each center requiring, either directly or indirectly, trunk facilities with every other center.

To keep abreast of the growing demands for telephone service intensive development work was constantly needed. Thus a continual introduction of automatic features into the manual system was found necessary to attain the speed, accuracy, and efficiency that modern telephone service requires. Although these efforts resulted in greatly improved telephone service, it soon became apparent that yet greater improvement would result from the development of a mechanical switching system in which the time lag of scheduled movements with cords, keys, and plugs is eliminated.

The development of fully automatic or dial systems, which could insure, during all hours, service of uniform speed and accuracy under the most-severe conditions, required the solution of many difficult problems. Before these were successfully solved, the engineering imagination and specialized experience of hundreds of engineers were called into action for this common purpose. This engineering was not confined to the design of telephone equipment but in many cases developments in manufacturing methods were required to make available the necessary equipment with the required accuracy at a reasonable cost.

AUTOMATIC TELEPHONE SWITCHING

Briefly, an automatic (or dial) central office must be capable of serving up to 10,000 subscribers with sufficient switches, trunks, and associated circuits to complete calls promptly under peak loads of traffic. The equipment automatically connects calling subscriber to called subscriber, releases lines when telephone receivers are replaced, transmits a busy tone signal when the called line is busy, connects calls for discontinued or unassigned numbers to an answering operator who informs the subscriber of the status of such a line, and connects the subscriber to an operator when assistance is needed such as for long-distance calls.

The manual system is one where the subscribers' lines terminate in answering jacks in the central offices. To complete a call the operator picks up the plug of the cord used in answering the calling line, locates the jack of the called line, and pushes the plug into it, Fig. 1.

In the machine-switching field, the manual plugs are replaced by brushes and the jacks by small terminals. The connections are made by electromechanical devices operating under the control of the subscribers' dial. One of the two systems, which have been used for some time, is known as the step-by-step system, and is generally applied in small cities where trunking problems are not so complicated. The terminals are stacked in banks of 100 which are arranged in 10 layers of 10 each, Fig. 2.

To select a connection, the brush is caused to move first vertically and then horizontally by means of electromagnets until the desired terminal is reached. The other system, known as the panel system, is used in the larger cities. The terminal banks consist of 60 sets of 100 terminals each, stacked vertically, Fig. 3. The brushes operate over parallel vertical paths and are moved by motor-driven friction rolls at the bottom of the frame.

In both of these types of dial switching, selections are made by base-metal sliding contacts. With such contacts and large motions of rather heavy moving parts, frequent maintenance of contact terminals is necessary to insure satisfactory performance from the standpoint of speech transmission.

In comparatively recent years, this has been the subject of intensive development by the various engineering forces of the Bell System. A new automatic switching system, known as

the crossbar,[3] was therefore developed in which contact is established by moving springs equipped with small bits of precious metal, affording the advantage of reduced time in establishing connections and providing satisfactorily quiet telephone circuits with lower maintenance. In addition, the new system introduces many other desirable features, including yet greater flexibility in trunking circuits.

This system has been manufactured now for several years and most of the new telephone exchanges in the larger cities are of this type. The switching circuits are wired to the contact springs of a relay-like switching device, known as the crossbar switch, and the connections are made through these switches by the rapid process of pressing contacts together through the operation of two properly selected electromagnets, Fig. 4.

The total movement in establishing a call has been reduced tremendously as compared with the earlier two systems.

CROSSBAR-SWITCH OPERATION

The crossbar switch, from which this system derives its name, is the basic switching unit of the system. This device is made in two sizes, one containing 20 "vertical units," Fig. 5, and the other containing 10. Confining our discussion to the 20-vertical-unit switch, there are three major functional parts, as follows:

(*a*) Twenty separate vertical circuit paths.
(*b*) Ten separate horizontal circuit paths.
(*c*) Mechanical means for connecting any one of the 20 vertical circuit paths to any one of the 10 horizontal circuit paths by the operation of electromagnets.

Each vertical unit of the switch contains an operating or holding magnet and 10 sets of contacts in a vertical row. Thus, with 20 vertical rows and 10 sets of contacts in each row, a total of 200 sets of contacts is provided in a rectangular field, one set of contacts at each "crosspoint." These crosspoints are operated independently of each other by a co-ordinate operation of horizontal and vertical bars. The horizontal bars are actuated by the 10 horizontal or "selecting" magnets, while the vertical bars are the armatures of the vertical or "holding" magnets. Any set of contacts in any vertical row may be operated by operating first the selecting magnet corresponding to the horizontal row in which the set of contacts is located and then operating the holding magnet associated with the vertical row. Since the contacts are held closed by the holding magnet alone, the selecting magnet is operated but momentarily, and is released as soon as the holding magnet operates. Other connections through the switch may then be made by the operation of the other selecting and holding magnets. Thus, as the switch is normally used, as many as 10 connections can be maintained at any one time through the switch, one for each of the horizontal paths.

The mechanical interlocking of the horizontal and vertical bars, which causes the operation of a set of crosspoint contacts, is shown in Fig. 6. Each horizontal or selecting bar is provided with 20 selecting fingers, which are made of flexible wire. These fingers are mounted at right angles to the bar, one at each of the vertical rows of contacts. In making a selection, the proper selecting bar is rotated through a small arc by its magnet and all 20 selecting fingers on that bar move into position under the operating cards of that row of crosspoints. The holding armature is then operated by its associated magnet, engaging the selecting finger at the crosspoint of the two bars and causing the corresponding set of contacts to operate. When the selecting magnet is released the selecting bar and the unused fingers are restored to normal and made available for other selections, but the selected crosspoint contacts will be held closed by the holding armature until the holding magnet is released at the end of the connection.

[3] "Crossbar Dial Telephone Switching Systems," by F. J. Scudder and J. N. Reynolds, *Electrical Engineering*, vol. 58, 1939, Trans. section, pp. 179–192.
"The Crossbar Switch," by J. N. Reynolds, *Bell Laboratories Record*, vol. 15, 1936–1937, pp. 338–343.

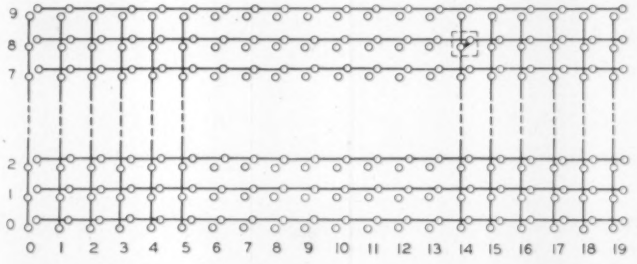

FIG. 4 IN THE CROSSBAR SWITCH, CONTACTS LOCATED AT THE INTERSECTIONS OF HORIZONTAL AND VERTICAL BARS ARE CLOSED BY THE OPERATION OF ELECTROMAGNETS ASSOCIATED WITH THE BARS

(Average motion per connection, $^{5}/_{32}$ in; armature movements of selecting magnet + holding magnet.)

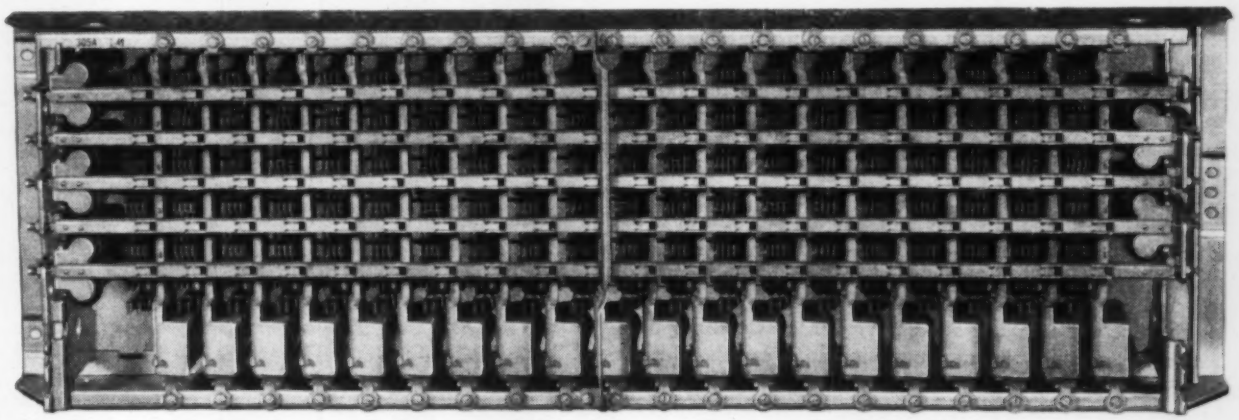

FIG. 5 CROSSBAR SWITCH CONTAINING 20 VERTICAL UNITS

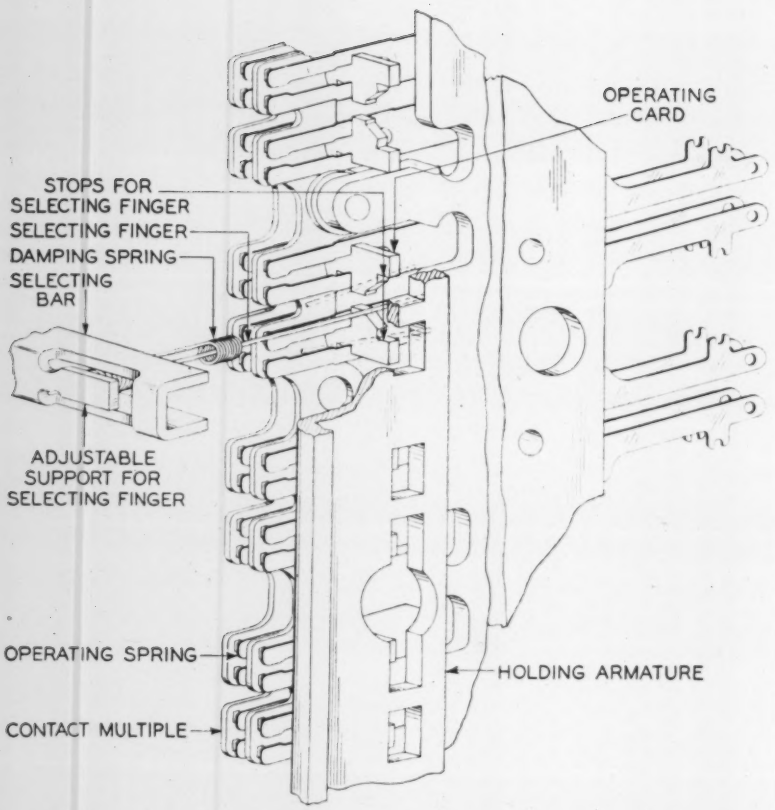

FIG. 6 MECHANICAL INTERLOCK OF HORIZONTAL AND VERTICAL BARS

Note that the selecting operation is performed by 5 horizontal bars, although there are 10 horizontal rows of contacts. This is accomplished by providing each selecting bar with a "butterfly" armature and two magnets, so that the bars may be rotated to move the fingers in either an upward or downward direction, the normal position for the fingers being midway between the crosspoint sets of contacts. The selecting bars are restored to the normal or mid-position by centering springs located at the end of the switch adjacent to the magnets. To reduce vibration on the operation and release of the selecting fingers, a small coiled damping wire spring is mounted on the fingers

In addition to the crosspoint springs, both the selecting and holding magnets may be equipped with "off-normal" contact springs which are operated by the armatures of these magnets whenever the latter are "off" their normal unoperated position. These contacts are provided for the various circuit functions common to all the crosspoint operations.

Since sliding contacts are avoided with this design, it is possible to have all the talking circuits connected through precious-metal contacts. Also, this type of apparatus, with its small pressure-type contact surfaces economically permits the use of twin contacts. These double contacts make for reliable operation, especially with the low speech and signaling currents inherent in a telephone system.

The short mechanical movements and correspondingly small operating time intervals permit the use of common circuits to control the operation of the switches. Large assemblies of switches and associated apparatus on unit frames can therefore be arranged so that they can be wired completely in the factory. Furthermore, the standardization of the relatively small number of different types of equipment and apparatus has also facilitated the manufacture as well as the merchandising of the system.

CONTACT-SPRING DESIGN

Looking more specifically now at some of the design problems, one of the most important features of the crossbar switch and one of considerable interest from the standpoint of mechanical design, lies in the development of the crosspoint contact springs. The contacts on these springs must be pressed together to give reliable connection—experience indicates that forces of the order of 20 grams (about $^3/_4$ oz) are required. In addition, by putting two contacts in parallel, the reliability of the contacts is increased still further; this is accomplished by mounting pairs of mating contacts on associated springs. The moving springs are bifurcated at the contact end, in order to enable the contact-carrying tips to act in great measure as if they were individual springs.

To assure contact between mating pairs involves not only the force required for satisfactory electrical connection, but also the force for bending the springs. Hence studies were required to determine the following:

1 The ratio of the required contact force to the force necessary to flex the spring to determine the required strength of the operating electromagnet.

2 The shape assumed by the spring during flexure, in order to allow for the motion in designing the electromagnet.

3 The stresses introduced in the spring when it is flexed. Since the springs may be flexed millions of times, it is important that the endurance limit of the material not be exceeded.

The springs used in the crossbar switch are essentially thin metal beams of a rectangular cross section but of varying cross-sectional area along their length. They are clamped at one end in the framework of the switch vertical units and are subject to bending as free cantilevers (before the contacts are closed) and as beams fixed at one end and supported at the other end by a rigid or elastic support (after the contacts are closed).

Fig. 7 shows one of the spring "layers," of which 3, 4, 5, or 6 are used depending upon the number of contacts per crosspoint

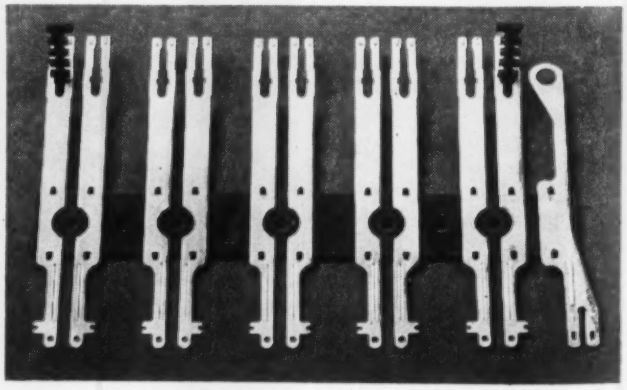

FIG. 7 ONE OF THE SPRING LAYERS USED IN THE CROSSBAR SWITCH

required by the circuit. To operate the contact springs by the pressure of the holding bar against the selecting finger, a hard-rubber "card" or "comb," as shown in Fig. 7, is used.

Obviously, it will be impossible to include in a paper of this

length the details of the theory of flexure of the "compound cantilever," as these springs may be called. The use of the differential equation

$$EI\frac{d^2y}{dx^2} = \Sigma M$$

for the deflection of beams permits the determination of the shape of the deflection curve of a spring due to the forces and couples applied. A spring of any number of sections all of which may be different in shape or composition (i.e., I or E may change from section to section) may be studied and its flexural properties obtained. This follows from the fact that, at the junction between any two sections of the spring (or beam), the slopes and deflections of both sections must have the same value, thus providing a relationship between the constants resulting from the integration of the moment equation.

To provide for economical manufacture, allowances must be made for manufacturing variations after the size, shape, and nominal locations of applied forces and contacts have been determined. Tolerance limits on dimensions establish most of these; however, the peculiarity of clamping the crossbar switch springs to the vertical-unit base requires special attention in the treatment of the length of the spring.

For electrical reasons, the contact springs are clamped between relatively soft insulating material (phenol fiber). It is difficult, in ordinary engineering problems, to fix a cantilever beam so that the tangent line at the built-in end remains fixed when the load is applied. The elasticity of the clamping for springs placed between phenol-fiber insulators exaggerates this effect; however, by means of a few simple measurements, the proper "end correction" can be determined. This method was developed by H. N. Wagar of the Bell Telephone Laboratories, and to the best of our knowledge has not been used heretofore.

The deflection equation for a simple cantilever is

$$y = \frac{PL^3}{3EI}$$

in which

P = load at free end
L = length of cantilever
E = modulus of elasticity
I = moment of inertia
y = deflection

or $\frac{y}{P}$ = compliance $C = \frac{L^3}{3EI}$, the deflection per unit load.

Now if the compliance is measured at several points along the length of the spring and the cube root of these values is plotted against the spring length as measured from some fixed point on the spring (such as the point where the spring enters the insulators), the result will be as shown in Fig. 8; the points will lie on a straight line which crosses the length axis at a value of L, which is less than zero. The spring thus behaves as though it were clamped rigidly at some interior point of the actual clamp, which is therefore the reference point for determining L, or the effective length.[4]

The accurate determination of the effective length of the spring is essential, as the cube of the length enters into the deflection equation. If, for example, we have a given force P, the actual deflection will be greater than that which would be calculated by using the measured length, by the ratio

$$\frac{[L_{\text{measured}} + \Delta L_{\text{(end correction)}}]^3}{L^3_{\text{measured}}}$$

[4] This method also provides a means for determining moduli of elasticity.

When dealing with deflections measured in thousandths of an inch, as is the case in the crossbar switch, it can be seen that considerable importance must be attached to the correct value of length in determining the deflection curve of the springs.

The cube of the thickness of the spring also enters into the deflection equation (since the moment of inertia is proportional to thickness cubed); for this reason thickness tolerances closer than generally used commercially are required. If, as would ordinarily be the case, springs of 0.010-in. ± 0.001-in. stock were used, the ratio of compliances between minimum and maximum springs would be

$$\frac{0.0110^3}{0.009^3} = 1.83$$

or the maximum-thickness spring would be almost twice as stiff as the minimum spring. By holding the tolerance limits to ± 0.0005 in. the ratio is reduced to

$$\frac{0.0105^3}{0.0095^3} = 1.35$$

or a spread of 35 per cent from minimum to maximum springs. A wide spread between minimum and maximum springs is undesirable in that the apparatus must be engineered to provide large margins in operating current for maximum springs and to allow for wider differences in operating and releasing times.

This is an excellent example of close tolerances being produced in the early stages of manufacture with the result that more uniform operating characteristics are obtained in the crossbar system.

In addition to these variables of length, thickness, and locations of applied force and contacts, consideration must be given also to the modulus of elasticity. In the manufacture of the springs, it is customary, for material saving, tool design, and ease of fabrication, to punch the springs out of raw stock of nickel silver, copper silicon, or phosphor bronze with the direction of the length of the spring being at an angle (often near 45 deg) to the direction of rolling (grain direction) of the material. Investigation has shown that the modulus of elasticity for a given material does not remain constant for all

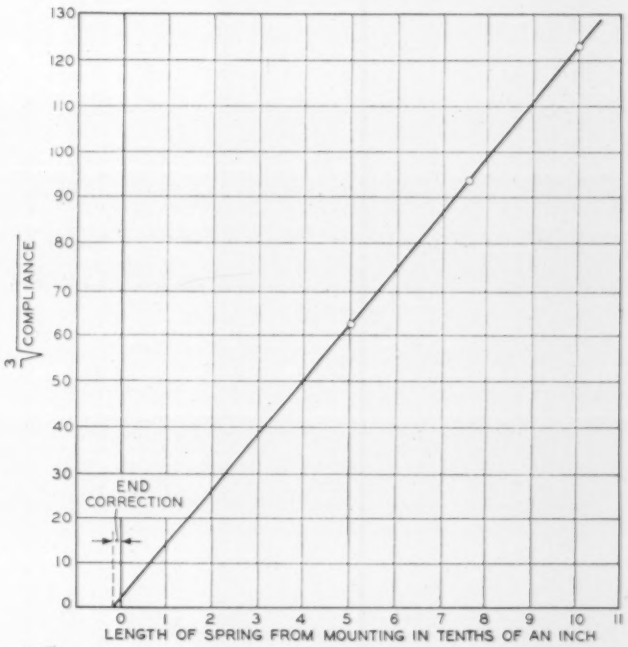

FIG. 8 DETERMINATION OF EFFECTIVE LENGTH

grain directions, but may vary widely as illustrated in Fig. 9. The modulus of nickel silver in particular falls and then rises as the length direction changes from 0 to 90 deg with respect to the grain direction, thus introducing an appreciable effect in the flexural properties of the spring. For example, if a spring formerly punched from nickel silver with the length parallel to the grain direction were to be changed to 45 deg to the direction of grain, the compliance would be changed in the ratio of 18.2: 20.6, or the spring would be only 88 per cent as stiff. In critical cases, it may be necessary to change the thickness of the spring by the cube root of the ratio of moduli, to compensate for the reduced compliance.

The variation in modulus between different materials is of paramount importance at the present time, since in providing substitute materials because of the war program, it is often necessary to change the thickness of the springs in order to avoid changing the operating characteristics. This creates manufacturing problems as well, because the tools may require modification to fit the fabricating properties of the substitute material. Also, changes in the associated parts may be necessary to compensate for the changed spring thickness.

CONTACT-SPRING OPERATION

The combination of the flexural characteristics of the springs with the distances through which they must be deflected both prior to and subsequent to contact closure, including the tolerances provided for dimensional and manufacturing variations, is most easily represented by graphs showing the relation between the total load and vertical- or holding-armature travel. Such a load characteristic is shown in Fig. 10. The area under this characteristic may be considered the work that must be done by the holding magnet to overcome the static load against the holding armature when selection of a crosspoint is made. To operate the load within a given time, however, the magnet must be capable of doing work in excess of that represented by the load characteristic to an extent determined by the required operating time.

It is not the purpose of this paper to enter into a discussion of the electrical characteristics of the crossbar switch; however, it will be necessary (and desirable) to mention briefly a few salient points in connection with the design of the electromagnets.

In its simplest form, the pull of an electromagnet may be represented approximately by the expression

$$\text{Pull} = \frac{(\text{Flux})^2}{8\pi \times \text{Area of pole faces}}$$

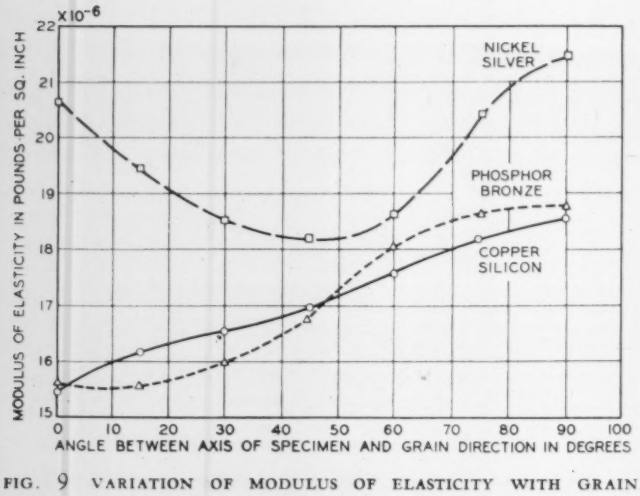
X10⁻⁶
MODULUS OF ELASTICITY IN POUNDS PER SQ. INCH
NICKEL SILVER
PHOSPHOR BRONZE
COPPER SILICON
ANGLE BETWEEN AXIS OF SPECIMEN AND GRAIN DIRECTION IN DEGREES

FIG. 9 VARIATION OF MODULUS OF ELASTICITY WITH GRAIN DIRECTION

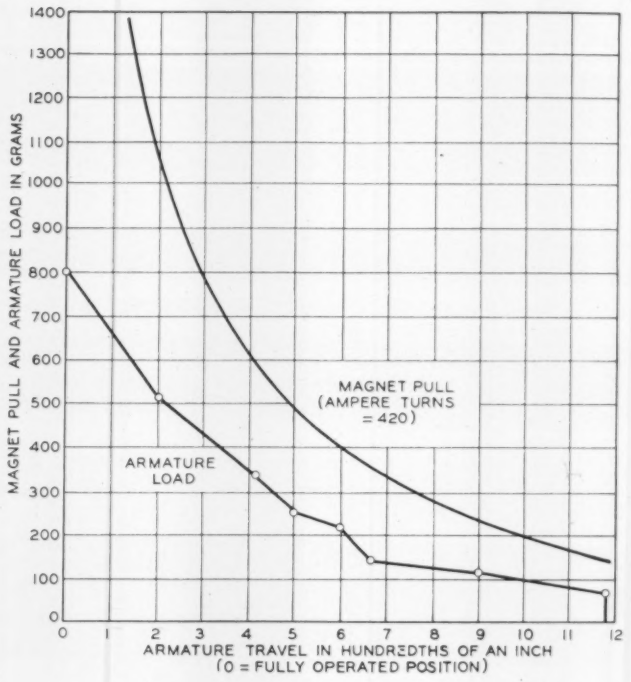
MAGNET PULL AND ARMATURE LOAD IN GRAMS
MAGNET PULL (AMPERE TURNS = 420)
ARMATURE LOAD
ARMATURE TRAVEL IN HUNDREDTHS OF AN INCH (0 = FULLY OPERATED POSITION)

FIG. 10 TYPICAL LOAD CHARACTERISTIC OF A VERTICAL UNIT AND ITS ASSOCIATED MAGNET-PULL CURVE

Since the flux is inversely proportional to the length of the gap, (or the armature travel at the core center line), this equation may be rewritten as

$$\text{Pull} = \frac{\text{Constant}}{(\text{Armature travel})^2}$$

This equation represents an inverse square curve of the form of $y = \frac{1}{x^2}$, for a given magnetomotive force (ampere turns), applied to the magnet. Again referring to Fig. 10, the pull curve of a typical magnet is shown above the load which it is required to operate. The greater area under the pull curve than that lying below the load characteristic represents the work available for accelerating the vertical-unit armature.

The designer of an electromagnet is usually faced with the necessity of providing a structure of sufficient pulling capability and operating speed to fit into the space allowed for the magnet by the mechanical design. As the result of considerable study, the final form of the crossbar-switch holding magnet became a "channel" type structure, in which the armature pivots on the edges of the channel, a method which permits the optimum location of the core with respect to the load of the springs to be operated,[5] Fig. 11.

For a given spring load a certain magnetic flux is required. Two considerations must be observed in supplying this flux, as follows:

1 The winding must contain the required ampere turns to provide the pulling flux, with sufficient margin to operate the armature in the required time.

2 Since the majority of the windings are held operated during a telephone conversation, the current drain on the power supply must not be so great as to warrant unnecessarily large power-plant capacity.

[5] The winding depth of either an L-shaped magnet or a channel-type magnet, with the armature pivoted over one edge, limits the distance of the core from the pivot edge.

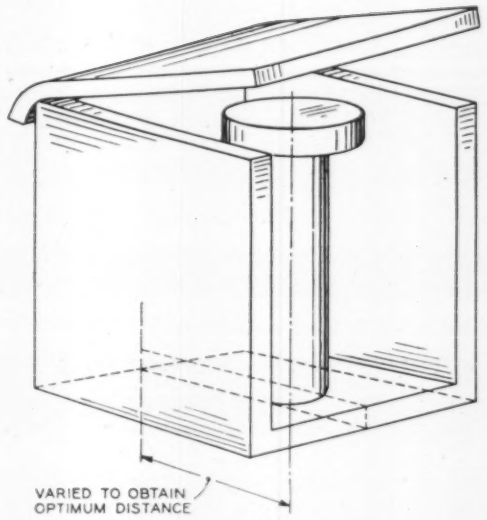

FIG. 11 MAGNETIC STRUCTURE OF VERTICAL-UNIT MAGNET

The coils are wound with a sheet of 0.0007-in-thick cellulose acetate between the layers of enameled wire. This construction provides a coil of excellent characteristics such as freedom from short-circuited turns, uniform resistance, closer control of the number of turns, and high breakdown strength; also, exhaustive tests indicate that, of the available materials which have suitable processing properties, cellulose acetate is superior from the standpoint of corrosion.

When designing the winding used on most of the vertical-unit holding magnets, it was found that the standard gage size of No. 38 B&S gage wire was too small to provide the ampere turns for the required operating time, while No. 37 wire resulted in coils of resistance so low as to make battery drain excessive. Rather than change the mechanical design to provide more space, a new gage size midway between the standard No. 37 and No. 38 was established. Although this was contrary to standard practice, the amount of wire used annually was of such magnitude (125,000 lb), and the need was critical enough from a capability standpoint, that the production of a non-standard wire in this instance was justified.

CONTACTS

That small bit of precious metal through which the talking currents, as well as some circuit-operating currents flow, belies by its minuteness the efforts expended in bringing it to its present state. In the early days of telephone communication, it was soon found that when circuits are completed by pushing circuit members together with small forces, precious metal is required at the contacting points. With base metals, unless there is large wiping action and frequent maintenance, tarnish films develop to such an extent as to create excessively high resistances in the circuits. Besides, when currents are interrupted, the resulting spark may heat the metal to a high temperature; hence, the high melting point of the precious metals is of considerable importance.

Prior to 1913, contacts were made in a dome-and-disk shape, each riveted to the supporting springs. Spot welding was introduced in that year and large reductions in the amount of contact material were possible, as well as the attainment of greater facility in manufacture. Continued investigation (and it is still going on) has found improved metals and alloys which provide greater reliability, ease of manufacture, resistance to wear from millions of contact closures, and lower cost.

The size of a contact is not only determined by the electrical erosion or mechanical wear, but is affected by two other requirements:

1 A pair of contacts must have sufficient height to provide enough separation to permit adjustment and to insure against springs touching.

2 Contacts must be of sufficient size to provide tolerances for the positioning of the contacts on the springs and for the alignment of mating contacts.

Studies of various shapes,[6] Fig. 12(*a*) have shown that, for a given erodible volume within the specified depth of wear, and to provide a certain tolerance for alignment, contacts in the shape of small bars placed respectively at right angles and along the length of the contact springs are most economical. The amount of metal required for erosion determines the cross section, while the alignment tolerances establish the length of the bars.

However, the height required for spring separation in most cases would result in a waste of precious metal, since the height required for erosion is much less than that required for spring separation. To provide the necessary height without an excessive use of precious metal, a combination of palladium as the contact metal in the form of a cap welded to a base of nickel is used, the cross section being formed especially for welding to the contact springs. The erodible volume is contained in the palladium cap, while the nickel base provides the additional necessary height, as well as a more satisfactory material for welding to the contact springs.

METHODS OF ANALYZING MOTIONS

The well-known stroboscope, now modernized with gas-filled lamps, is a common tool used extensively in the observation and study of rapidly moving parts where the phenomena are recurrent at a fixed frequency. Unfortunately, the motions in which we are interested in the crossbar switch are not always of this kind. For example, the motion of the armature is affected by the load changes occurring during the armature stroke, as shown in Fig. 10. The armature moves rapidly through the first part of the stroke; as the moving springs are picked up, the armature slows down and, under severe

[6] "Contacts for Crossbar Apparatus," by B. F. Runyon, *Bell Laboratories Record*, vol. 18, 1939–1940, pp. 278–282.

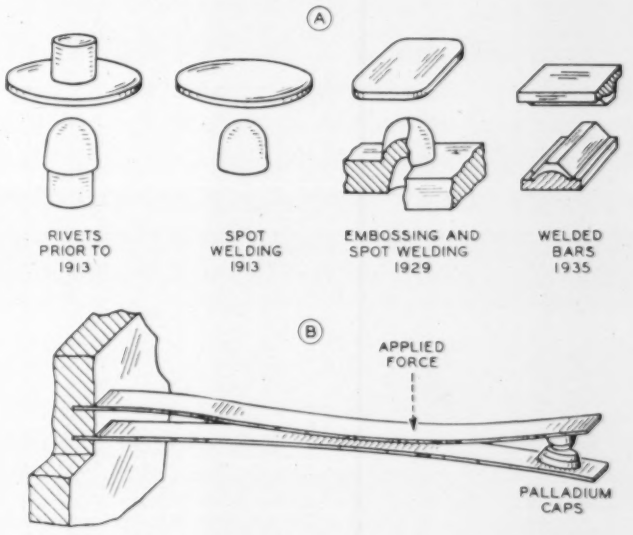

FIG. 12(A) VARIOUS TYPES OF RELAY-SPRING CONTACTS

FIG. 12(B) DEFLECTION OF CONTACT SPRINGS
(Contacts and deflection exaggerated to emphasize action.)

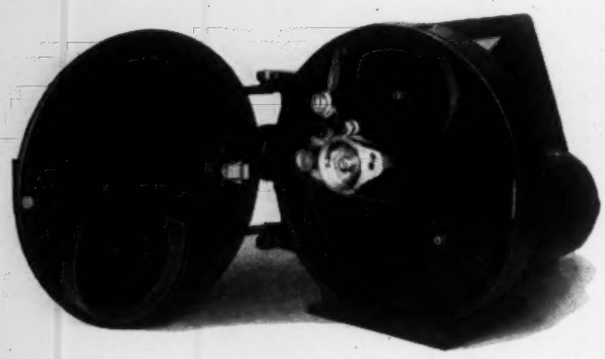

FIG. 13 HIGH-SPEED MOTION-PICTURE CAMERA USED IN ANALYZING CROSSBAR-SWITCH OPERATIONS

load conditions, when the contacts close, the load may be great enough actually to stop the armature momentarily until the magnetic flux in the coil builds up sufficiently to complete the armature stroke.

To analyze this motion, as well as to study other moving parts of the switch, two methods have been used in the Bell Telephone Laboratories and modifications of standard equipment as well as development of new equipment have been required. One of these, the high-speed motion-picture camera, Fig. 13, enables the engineer to take pictures at speeds considerably higher than those obtainable with commercially available cameras and then to project them at lower speeds in order to magnify time.

To obtain a series of pictures of extremely rapid motion would be impossible with the usual motion-picture camera having a shutter and mechanically operated claw mechanism for bringing the film into position and holding it for sufficient time to permit the proper photographic exposure. The mechanical inertia of the parts would prevent the camera from operating at the requisite speed with sufficient fidelity of positioning the film uniformly and smoothly behind the lens.

The camera[7] used in the Bell Laboratories is of the "optical-compensator" type, the compensator consisting of a small cube of optical glass revolving back of the lens in synchronism with the motion of the film. This cube creates successive images on the continually moving film, thus permitting a longer exposure without blurring than is possible by the flash method used in other systems of high-speed photography.

By driving the film through the camera at about 70 mph (100 fps), pictures are made at the rate of 4000 frames per second. When projected at the normal speed of 16 frames per sec, a time magnification of 250 to 1 is obtained. Thus it is possible to observe readily the operation of fast-moving mechanisms, and if necessary, make frame-by-frame measurements to obtain quantitative data. Quite often, however, being able to observe the action of a device is all that is necessary to suggest to the engineer certain refinements necessary for the best over-all performance.

A second device providing facilities for motion analysis makes use of the "rapid-record" oscillograph.[8] This oscillograph was developed to eliminate the many complications and delays which make the ordinary vibrator type of oscillograph unsatisfactory for use where time is at a premium. A record of electrical action is obtained on a moving photographic paper by the shadows of as many as six strings which vibrate in the path of a beam of light. The paper then passes through a developing and fixing tank and within 1 min after the circuit is closed to start the operation, a complete oscillogram is ready for study. Fig. 14 illustrates the operation of the oscillograph.

To study mechanical motion, this apparatus is provided with an optical system whereby a shadow of the moving part is recorded on the same oscillogram with the oscillographic record of associated electrical phenomena.[9] An edge of the moving part or a light target, mounted on the moving part, is

[7] "High-Speed Motion Pictures Aid Design," by J. R. Townsend, *Electrical Engineering*, vol. 59, 1940, pp. 448–450.

[8] "A Rapid Record Oscillograph," by A. M. Curtis and I. E. Cole, *Electronics*, vol. 3, August, 1931, pp. 70–71.
"A Rapid Record Oscillograph," by A. M. Curtis, *Bell Laboratories Record*, vol. 8, 1929–1930, pp. 580–585.
"The Six String Oscillograph," by A. M. Curtis, *Bell Laboratories Record*, vol. 13, 1934–1935, pp. 145–150.

[9] "Vibration Studies With the Rapid Record Oscillograph," by H. E. Hill, *Bell Laboratories Record*, vol. 16, 1937–1938, pp. 26–30.

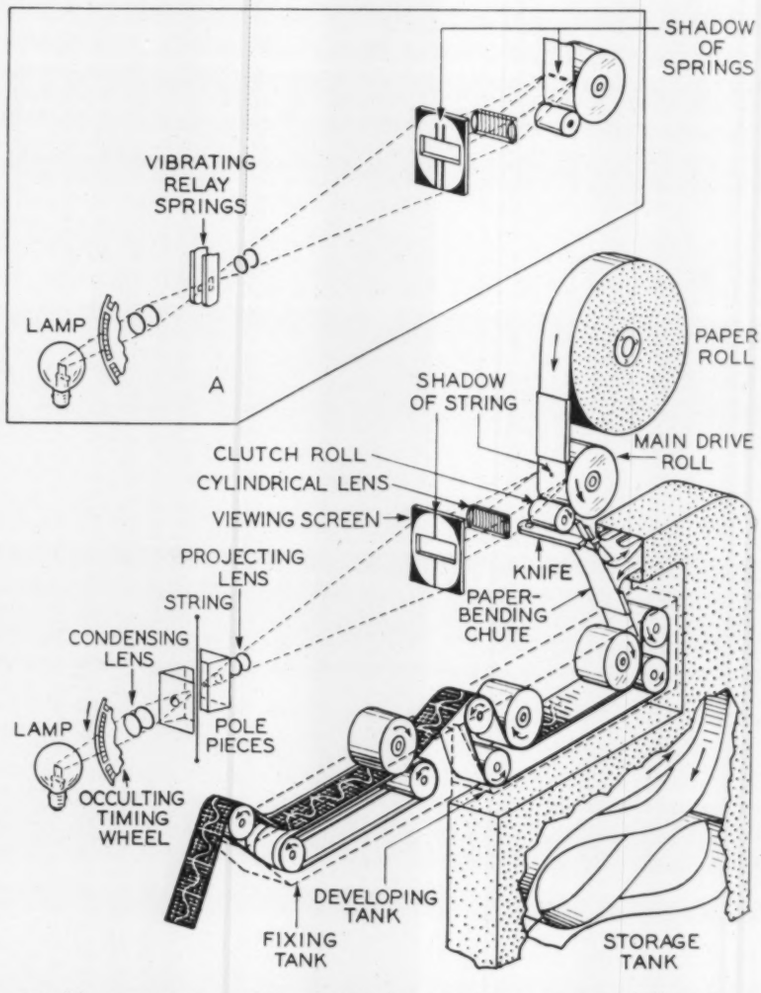

FIG. 14 OPERATION OF RAPID-RECORD OSCILLOGRAPH. INSERT "A" SHOWS METHOD OF OBTAINING SHADOWGRAPH OF VIBRATING RELAY SPRINGS

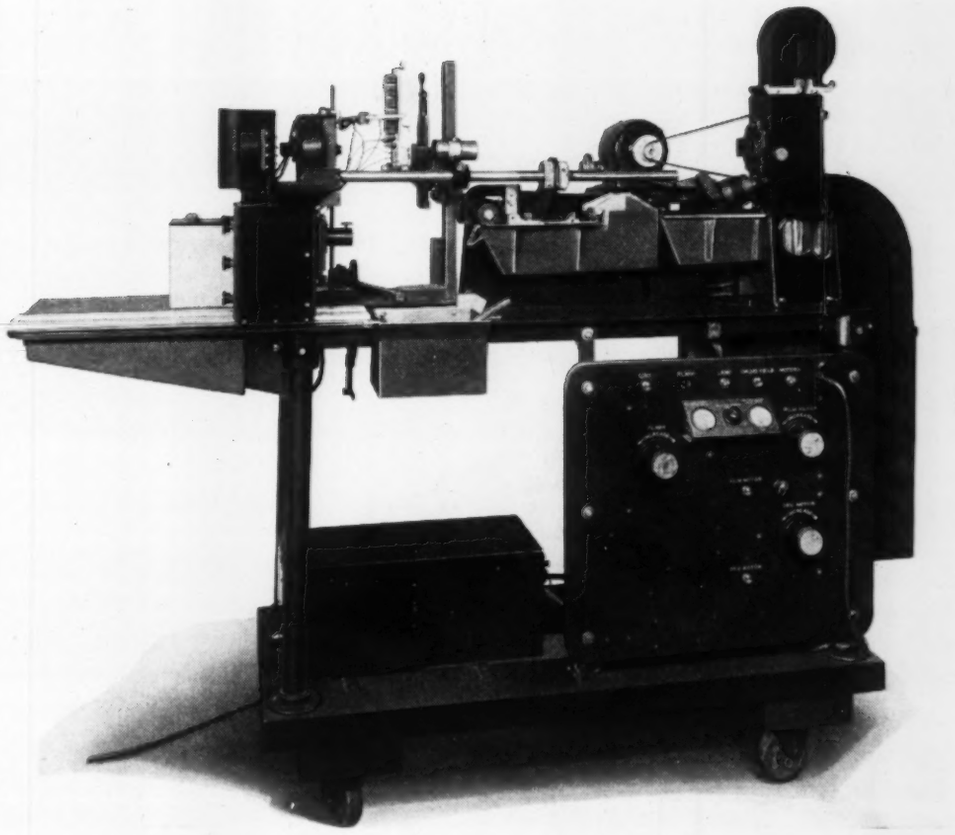

FIG. 15 APPARATUS SET UP FOR SHADOWGRAMS OF A CROSSBAR-SWITCH VERTICAL-UNIT ARMATURE

positioned in the same light beam which records the shadows of the oscillograph springs. The principle by which the shadowgram is obtained is shown in Fig. 14, insert "A."

Fig. 15 shows the apparatus set up for measurement, on a crossbar-switch vertical unit, of the winding-current (magnetomotive force) magnetic-flux change, and operating time of the contacts, all combined with the time-displacement characteristics of the armature. The latter may readily be observed in the high-speed motion pictures; however, to obtain the time relationship with magnetizing force and flux build up, the shadowgraph is of great value. An example of such a record is shown in Fig. 16. This shadowgram represents an early condition in the crossbar-switch development which caused false circuit operation. A preliminary closure of the crosspoint contact occurred, because of the armature's stopping and actually moving backward for a few thousandths of a second as shown by the shadow on the oscillogram. This was caused by the lag of the magnetic flux in building up to a sufficiently high value to overcome the force of the springs against the armature. Based upon this type of analysis, a study of the vertical-unit loads and magnet structure enabled the designers to eliminate the false contact closure.

With these devices, therefore, it is possible to obtain both quantitative and qualitative data on any of the moving parts of the switch, or wherever vibration of the parts might be set up by transmission of shock from the moving armatures, or other moving apparatus on the same frame with the crossbar switches. Design improvements, when needed, are introduced after careful studies of such data as these.

(To be concluded in the June issue)

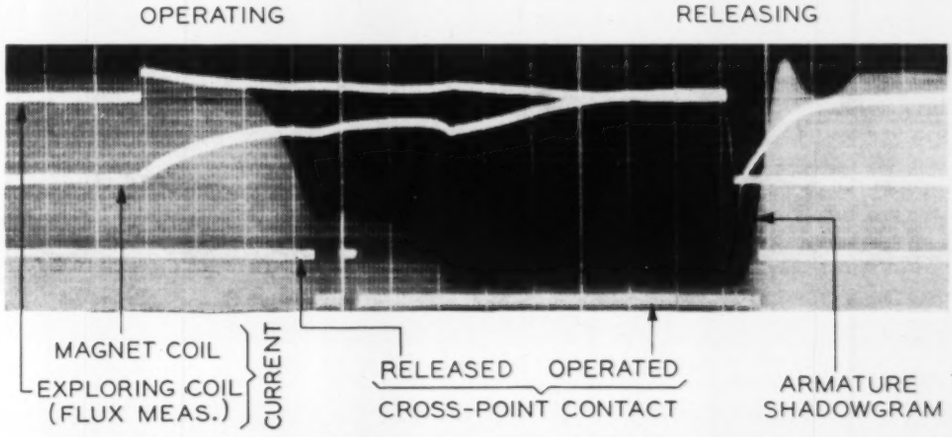

FIG. 16 SHADOWGRAM OF MOTION OF VERTICAL-UNIT ARMATURE

TECHNOLOGY IN OUR ECONOMY[1]

By ARTHUR A. BRIGHT

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE effects of changes in technology upon the welfare of individuals in a society have been disputed for many years. Such discussions are still continuing. Judgments at the present time are based to an increasing extent upon factual evidence, however, and to a lesser extent upon the personal feelings or desires of the disputants. In connection with the U. S. Senate's investigation of concentration of economic power, the Temporary National Economic Committee has had prepared a monograph[2] on "Technology in Our Economy."

This monograph provides what is perhaps the most comprehensive treatment of the problem which has ever been undertaken in this country. It is frankly not intended to contribute by breaking new ground. Its contribution lies in the assimilation of significant theories and studies to date, blending them into a comprehensive picture of the problem as it stands today.

Improvements in technique, often involving the introduction of "labor-saving devices," are opposed by many groups as the source of widespread, continuous unemployment. New industries, on the other hand, are hailed by many as sources of employment and prosperity. Actually, neither type of development is an unmixed curse or blessing. Fair judgment can be based only upon determination of the net resultant of all beneficial and detrimental effects of such a change, *both direct and indirect*. A characteristic of most studies to date, and a limitation of the T.N.E.C. monograph, is that direct effects are given disproportionate attention. It is true that they are the most readily discernible effects, but it is not necessarily true that they are quantitatively the most important. Only close study of specific changes, following through the indirect effects on other industries as well as the one primarily concerned, can provide grounds for correct conclusions.

TRADITIONAL THEORY OF COMPENSATORY FORCES

The traditional theoretical analysis of technological change stresses the nature of the compensations inherent in such situations. When new improved techniques are discovered, so the theory runs, workers may be displaced in the first instance. The same output can be produced more cheaply, and the element of competition in the market will force prices down to the level of the new lower costs. At the lower price, sales may expand considerably, reabsorbing those workers originally displaced. If sales do not increase sufficiently, consumers will be able to use the purchasing power released by the fall in prices in purchasing other commodities. The displaced labor will then be reabsorbed in these other industries as they expand output.

According to this analysis there can be no technological unemployment. Some economists argued in this vein during the early nineteenth century. There are some still arguing this way today, as part 1 of the monograph points out in its historical survey of the problem of technological unemployment. Those who argue in this manner do admit, perhaps, that some slight temporary dislocations may exist, but insist that these are of little general significance though they may be of great importance to the workers displaced. Such an attitude overemphasizes the economic tendencies and underemphasizes the obstacles to the working out of these tendencies. At best, considerable time is required for prices to fall and output to expand and workers to find re-employment. Prices may fall very little or not at all, however, if the market is not highly competitive.

RESULTS OF TECHNOLOGICAL ADVANCEMENTS

The T.N.E.C. monograph attempts, in part 2, to present briefly an accurate factual picture of changes in labor productivity, the extent of primary labor displacement, and the extent to which the compensatory forces have brought about reemployment at higher levels of output. The data used by Mr. Blair in writing this part were obtained almost entirely from other studies. Yet this is the first major attempt to bring them together to provide a balanced picture of the effects of technological change upon the economy. There is still much to be desired in the way of completeness, but the achievement is nonetheless notable.

To provide the groundwork for a study of the effects of technological change upon workers and the nation, Mr. Blair devotes a chapter to a discussion of the extent of changes in labor productivity and the types of labor-saving techniques. Where labor productivity increases without a concurrent increase in output or decrease in working hours, it is clear that some workers will lose their jobs. Labor productivity is represented by output per man-hour, "because reductions in hours or changes in price do not affect its validity."

Data are not available for all years in all industries, but the monograph does give striking evidence of continuous increases in productivity for many important industries. The increase in productivity from 1909 to 1939 for manufacturing industries was from 66.2 to 174.5, where 1923 equals 100. Productivity in steam railroads rose from 78.2 to 154.9 during the period 1914 to 1939. In many lesser industries the increase in productivity has been even greater. Speaking of the two industries specifically mentioned here plus anthracite and bituminous-coal mining, Mr. Blair says:

"Labor productivity in these four fields has made striking advances, reaching an all-time high in 1939. It has been relatively unaffected by the major cyclical downturns and, except for a few brief interruptions, has steadily increased. The principal variation in the productivity trend has been in its rate of advance, and in three of the fields the rate has greatly accelerated in the last decade."

Causes for the extensive increases in productivity are to be found in several factors, according to the monograph. Labor productivity tends to advance as a greater degree of standardization is achieved. Efficiency also tends to rise with increasing production as specialization is carried to greater lengths. By far the most important source of increased labor productivity is in improved techniques of production, however. The monograph provides a classification of types of labor-saving techniques. All are of great importance in increasing output per man-hour in the economy. The classification includes: power and energy development, material changes, process changes, use of individual single-function machinery, and improved management methods. Examples are cited for each of these

[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "Technology in Our Economy," Temporary National Economic Committee Monograph No. 22, by Lewis L. Lorwin and John M. Blair, United States Government Printing Office, Washington, D. C. 1941.

classifications. Added to one's own information, they make it quite clear why labor productivity has shown such a steady rate of increase, even during the thirties which were, in general, years of depressed business activity.

DISPLACEMENT OF LABOR

Ever since the effects of technology upon the economy have become noticeable, attention has centered mainly upon technology as a cause of unemployment. The monograph is no exception to this tendency. In most industries there was little, if any, increase in production from 1929 to 1937. During this time labor productivity had continued to advance, however, so that employment in most industries fell considerably. From 1929 to 1939, years approximately comparable in output, man-years employed in manufacturing fell 24.8 per cent, from 8,368,800 to 6,290,186 according to the U. S. Bureau of Labor Statistics data. The monograph quotes David Weintraub's estimate that improvements in efficiency in the period 1920 to 1929 "displaced 2,832,000 men, or 416,000 more than were reabsorbed into manufacturing by the shortening of the work week and the increase in total output." The fact that large-scale, continuous displacement exists as a result of productivity increase is undeniable, though estimates of its size may vary somewhat.

That this displacement is not a short-term matter for the workers losing their jobs is indicated by sample studies made by the National Research Project of the Works Progress Administration. A study of unemployment in Philadelphia in May, 1937, revealed that 48 per cent of unemployed men and 34.9 per cent of unemployed women had been without private jobs for two years or over. At that time industrial production was 118, as compared with 122 for May, 1929, according to the Federal Reserve Board.

Most of the unemployment of the thirties was due to the cyclical depression of production, without doubt, but a sizable percentage of unemployment may be traced directly to technological factors. That so many displaced workers remained unemployed after two years, however, resulted primarily from the existence of many of the same obstacles to "compensation" that lead to continued business cycles. Many problems arising out of advancing technology should be discussed in connection with cyclical fluctuations in production and employment. This has been recognized by some theoretical writers for a long time, but has not been reflected to an appreciable extent in the studies upon which the T.N.E.C. monograph was based or in the monograph itself.

THE COMPENSATORY FORCES

Having set forward some of the facts of increasing productivity and the immediate displacement of labor resulting from it, the monograph goes on to the treatment of the observable facts of compensatory increases in employment. This aspect of the analysis is less satisfactory, inasmuch as factual evidence of secondary reactions is far scantier than evidence of primary reactions. As principal compensatory forces, Mr. Blair points to the reduction in working hours, reductions in prices, and the development of new industries.

As output per man-hour increases, the total number of man-hours required will decrease unless total production rises commensurately with productivity. Production in most lines has not maintained that pace since 1929. The downward trend in hours worked per week which had persisted for many decades was accelerated after 1929, as government, unions, and employers saw the necessity of "spreading the work" to minimize unemployment. The 1929–1933 production decline was mainly responsible for the acceleration of the downward trend in worker hours, but factors of increased productivity intensified it. The monograph offers some statistics on changes in hours, but for the most part leaves it to the reader to make his own analysis and draw his own conclusions. Considering the over-all unemployment figures of the thirties, it is apparent that shortening the working week to forty or less hours in trying to overcome cyclical unemployment is ineffective. It is not apparent, however, to what extent the shortening of the working week tended to compensate for displacement of labor as a result of productivity increases, either before or after 1929.

In its discussion of the reduction of prices, the monograph is again rather brief, offering in an appendix factual data concerning changes in productivity and prices of selected industries. For an extensive examination of price behavior, Mr. Blair refers to T.N.E.C. monograph No. 1, "Price Behavior and Business Policy." Mr. Blair emphasizes the great importance of price changes in compensation, but leaves the reader somewhat up in the air regarding the extent to which compensation is achieved by price reductions. The conclusion he draws is that, in industries in which output is concentrated in the hands of a few leading firms, unit labor requirements usually tend to decline more extensively than prices, while in nonconcentrated industries unit labor requirements rarely decline more extensively than prices. To the extent that concentration is widespread among many American industries, compensation is hindered. The monograph does not advance any quantitative measure of compensation, or lack of compensation, from price reductions, however.

As concentration in an industry increases, price rigidity also tends to increase. The monograph therefore concludes that improvements in technology may actually handicap the compensating forces, inasmuch as improved technology is "one of the primary causes of this concentration." The growth and concentration of industrial research in a relatively small number of large corporations is pointed to as one reason for the concentration of production. Here again, though the tendency noted may be correct, its value in appraising the compensatory effect without some quantitative estimate is limited.

The development of new industries is the final compensatory force discussed in the monograph. "Technology, by bringing forth new industries, causes the economy to expand along three major fronts: (1) Employment opportunities are created for large segments of the working population in the fabrication of the new product; (2) the capital-goods industries are stimulated by the placement of orders for needed productive equipment; (3) new industries frequently create activities in the fields of distribution, transportation, service, and maintenance." Thus, technology, by bringing forward new products which provide employment opportunities, aids in balancing the displacement brought about by improvements in technique. When machines are substituted for labor in the development of new processes, a part of the displacement is taken up by the labor required in making the machine and in its maintenance thereafter.

New industries are unquestionably important in providing employment opportunities. Eighteen new manufacturing industries which came into existence since 1879 absorbed almost one seventh of all the labor employed in manufacturing in 1929. That figure is probably considerably larger now.

To quote from the monograph: "It is while new industries are rapidly expanding that they are most effective as stimulants to economic activity. New plants are constructed, new workers are hired, and a new demand is created for materials. The importance of a new industry diminishes, however, as it develops sufficient capacity to meet a foreseeable demand, and as the capital-goods industries supplying the necessary productive equipment expand to a point where they can meet any expected demand from the new industries."

This indicates, though it is not emphasized sufficiently in the monograph, that the investment aspects of technological advance are of great importance, as well as the employment opportunities in turning out the product. Investment in new plant and equipment tends to stimulate the entire economy, possibly having favorable effects on industries entirely unrelated to the one where the technological change takes place. Two qualifications must be made, however. First, many technological advances, particularly those of a chemical nature, tend to be capital-saving, and so tend to require small investment. Secondly, the investment induced and the employment provided must be weighed against the investment replaced elsewhere and the displacement of other goods. In short, the matter of investment as well as of employment is a matter of *net* increases or decreases.

Those industries long mentioned as having great promise for the future are discussed, but Mr. Blair concludes pessimistically that they offer no really outstanding employment possibilities. Prefabricated housing, air-conditioning, television, and Diesel engines are suggested. For various reasons, none seems to Mr. Blair able to provide great stimulus to expansion. He makes little or nothing of the more subjective but no less desirable increases in enjoyment obtained by consumers from newly developed products and improvements in old products.

The discussion of each of the suggested compensatory forces concludes on an unhappy note, therefore, with the monograph's final conclusion that "under present conditions unbalance will continue and perhaps even become more pronounced."

This is a most dismal prospect. As based on the evidence presented, it may be justified as a working hypothesis, but it seems to this reviewer that final judgment cannot be made without a far more thorough investigation of the compensatory forces in a large number of specific cases. Quantitative information is necessary, not alone on primary displacement, but upon secondary effects as well. Re-employment resulting from expanded output, increases or decreases in employment in related industries, the favorable or unfavorable effects on net investment—these must all be known. The monograph presents quantities of factual data on displacement, but is noticeably weak with respect to facts on the compensatory forces. Extensive investigations must still be made before satisfactory conclusions may be drawn.

Despite its weaknesses, however, this T.N.E.C. monograph is a valuable addition to the literature in the field of the economics of technological change. By discussing the historical development of theories of technical change in part 1, and by presenting systematically in part 2 some of the best of the factual data available from studies made in the last few decades, it paints a fairly good picture of the role of technology in our economy.

A.S.M.E. Code for Unfired Pressure Vessels

Proposed Revision of Section VIII, A.S.M.E. Boiler Construction Code

IN the January, 1938, issue of MECHANICAL ENGINEERING, page 89, announcement was made of a modified plan for the revision of Section VIII of the A.S.M.E. Boiler Construction Code. This plan was outlined in considerable detail, and criticisms and suggestions were invited thereon.

The Special Committee of the Boiler Code Committee to Revise Section VIII has recently completed a preliminary draft of the proposed revision.

The general arrangement of the draft is quite similar to that followed by the API-ASME Code for Unfired Pressure Vessels. The important changes between the present Section VIII and the proposed revision can be briefly summarized as follows:

(1) The uses to which vessels built under a given set of requirements can be put on account of the difference in the hazard involved, which are now specified in Pars. U-68, U-69, and U-70, have been eliminated except for vessels containing lethal liquids and gases which are required to be both stress-relieved and radiographed.

(2) The efficiencies of fusion-welded joints are the same as given in the API-ASME Code.

(3) The rules for determining the shell thicknesses of vessels include an additive thickness for corrosion designated by c in the formulas. The added thickness c may be zero when previous experience has shown that corrosion does not occur. For air, steam, and water vessels, c is to be made equal to $t/6$, except it need not exceed $1/16$ in.

(4) Provision is made for a minimum factor of safety of four for vessels constructed of steel plate.

(5) Appendix A will contain recommendations which will not be mandatory for periodic inspection, repair, and maintenance, and allowable safety valve settings for vessels in service. They are adapted particularly to the oil-refining industry.

(6) Mandatory rules have been included for trepanning specimens from the main welded joints, where such vessels are not radiographed and have plate thickness in excess of $1/4$ in. However, local radiographic examination of the welded seam may be substituted.

(7) Premiums are allowed for the work performed on the vessel, the greatest premium being for a vessel which is radiographed. Where mandatory stress relieving and/or radiographing is not required either or both of these operations may be performed and the premiums used accordingly.

(8) The hydrostatic and proof tests follow closely the requirements of the API-ASME Code.

Although the draft has been submitted to the members of the Boiler Code Committee, it has not been discussed by them and is therefore subject to possible change. However, the Committee has decided to release this preliminary draft for general distribution and critical review, in order to expedite the work as much as possible. Comments are invited from all interested parties, with the request that they be received by the Secretary of the Boiler Code Committee not later than July 1, 1942.

Copies of this draft may be obtained from the A.S.M.E., 29 West 39th St., New York, N. Y., at $1 per copy.

The personnel of the Special Committee is as follows: E. R. FISH, Chairman, Hartford, Conn., R. E. CECIL, Oakmont, Pa., A. J. ELY, Elizabeth, N. J., D. S. JACOBUS, Montclair, N. J., K. V. KING, San Francisco, Calif., C. O. MYERS, Columbus, Ohio, D. B. ROSSHEIM, New York, N. Y., WALTER SAMANS, Philadelphia, Pa., H. S. SMITH, New York, N. Y., and Walter STEGGALL, Technical Editor, Jersey City, N. J.

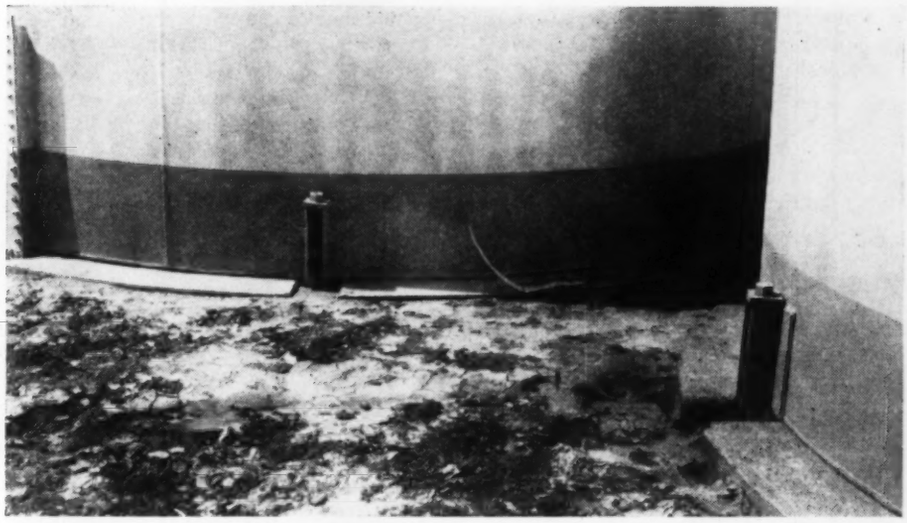

FIG. 1 TANK TIEDOWNS

Design of OIL-FIELD TANK BATTERIES *for* CONSERVATION

By ROSS M. STUNTZ, JR.

GULF OIL CORPORATION, GYPSY DIVISION, TULSA, OKLA.

At the present time, when the entire world is at war, and when battles are being won by planes and tanks which consume vast quantities of petroleum products, it behooves each and every one in the industry to conserve this most important natural resource. Prevention of the evaporation losses from crude oil is conservation in the truest sense. Once the higher gravity components of crude oil escape to the atmosphere in vapor form, they are forever lost.

A majority of these losses can be economically eliminated by a redesign of the tank battery as a whole from a conservation viewpoint. It is even quite possible economically to overhaul old tanks and tank equipment in order to conserve the lighter fractions. However, proper design of the material features of a battery is not sufficient; it is equally important that the men charged with the care and operation of tank batteries regard them as the specialized equipment that they are. A tank battery is more than just so many cans containing oil, or a place to store oil until it is sold. The tanks in modern batteries could be classified as low-pressure, semiportable, or fully portable graduated vessels for the safe and economic storage and handling of crude oils. Their mechanical features, such as valves, especially deserve cleanliness, care, and protection. Their surfaces, inside and outside, should be kept clean and protected from corrosion and deterioration. Lacking this attitude, devices designed to promote conservation cannot be expected to function satisfactorily.

Contributed by the Petroleum Division and presented at the Spring Meeting, Houston, Texas, March 23–25, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

It is not intended that this paper shall present numerous examples to prove the value of proper tankage and tank equipment in the production and handling of oil. However, it is proper to present a brief review of the progress which has been made in this field and of the losses which still exist.

AVERAGE EVAPORATION LOSSES

Some twenty years ago, J. H. Wiggins, in a U. S. Bureau of Mines paper, estimated that the average evaporation losses from well to refinery were in excess of six per cent. Numerous improvements in tankage and transportation, a realization that certain production methods are detrimental to gravity, and payment of a premium for higher-gravity crude oils have reduced evaporation losses to approximately two per cent. Although losses of two per cent seem small, if they are measured in dollars, the total value of the evaporation losses is enormous. Two per cent of the present daily United States production, about 4,000,000 bbl, amounts to 80,000 bbl per day, or 30,000,000 bbl per year.

Obviously, if a portion of the lighter constituents in a mixture of hydrocarbons, such as crude oil, is evaporated, the remaining oil will have a greater weight per unit volume than the original crude, that is, the specific gravity will have been increased and the A.P.I. gravity will have been decreased. By experiment, it has been found that there is a relationship between the percentage of crude-oil volume evaporated and the reduction in A.P.I. gravity. The relationship is this: The evaporation of 2.6 per cent of the volume of a crude oil having an A.P.I. gravity of from 30 deg to 42 deg will result in a reduc-

tion in A.P.I. gravity of one deg for that oil. The relationship as stated is an average figure for this range of A.P.I. gravity. The existence of this relationship justifies the use of the phrase, "conservation of gravity," to denote the prevention of evaporation losses from crude oil. As the portion which most readily evaporates is the more valuable part of the crude, purchasers in many areas pay a premium for higher-gravity crude oils, i.e., those in which the lighter fractions have been retained.

Therefore, in addition to the value of the evaporated production, that which remains has a lowered gravity and commonly sells at a loss of 2 cents per barrel for the reduction of each degree of A.P.I. gravity. Assuming that the A.P.I. gravity for one half of the total production has been reduced to the next gravity bracket, the loss sustained through price differential is $\$0.02 \times (4{,}000{,}000 - 80{,}000)/2 \times 365 = \$14{,}300{,}000$. At an average price of $1 per bbl, the volumetric loss is $30,000,000 per year. The total loss is, then, $44,300,000 per year.

Undoubtedly, some of the losses included in this immense figure can be designated as unavoidable. They occur in areas of flush production before gasoline plants can be installed, and in some older and smaller pools in which condensation and recovery of rich vapors in plants cannot be economically justified. However, there still remains a staggering figure which must be chargeable to waste.

In the normal production of oil, there are four points at which vapors leave the crude. These are: (1) separator, (2) treating plant, (3) field-stock tanks, and (4) pipe-line storage.

As previously stated, this paper deals with those losses which occur in field-stock tanks and with the methods by which these losses may be diminished. After experimentation at numerous tank batteries in the mid-continent area, it is estimated that the losses incurred in filling and temporarily storing lease production may amount to 1 per cent and, in some cases, more.

It would be a proper question to ask: Although these losses seem enormous when calculated on a national basis, are they of sufficient magnitude to justify the installation of proper tankage and gravity-control equipment on leases making 50 bbl or less? The answer is Yes!

EXPERIMENTAL INSTALLATIONS

Experimental installations on various leases in Glenn Pool, in Burbank, and at several other locations have revealed that the proper tankage and gravity-control equipment will effect sufficient additional revenue to pay for their cost of installation in a relatively short period of time. There are many tank batteries at which the A.P.I. gravity of the oil being sold could be raised one degree through the use of gravity-control equipment. This becomes important when it is realized that such a change would increase the sales revenue by as much as 4.6 per cent. This is based upon the premium of two cents per bbl being paid for each additional degree of A.P.I. gravity and a 2.6 per cent increase in volume of sales. This additional revenue will pay for tightening up the tanks and the installation of gravity-control equipment in 6 months and will even recompense the producer for a complete new tank battery, designed from a conservation viewpoint, in three years or less. Therefore, by accepting these statements which are matters of record and not mere conjecture, it can be stated that:

1 Existing evaporation losses from lease tank batteries can be drastically reduced.

2 It is economical to do so.

CONTROLLING VAPORIZATION

Vaporization of a given crude oil depends upon the following factors:

1 *Pressure.* Vaporization is inversely dependent upon the pressure maintained in the tanks, that is, the higher the pressure, the less the vaporization.

2 *Surface Exposed for Vaporization.* Other factors being equal, nearly 5 times the vaporization would occur in a tank 22 ft in diam, as compared to one 10 ft in diam.

3 *Temperature.* Vaporization of a given crude is directly dependent upon the tank temperature; the higher the temperature, the greater is the molecular activity and the greater the vaporization.

4 *Agitation.* Vaporization is increased by agitation.

Therefore, if these factors can be controlled, then the losses suffered by vaporization can also be controlled. The degree to which these losses are diminished must obviously depend upon the control exercised over the factors governing vaporization.

The first requirement for control of the factors which govern vaporization is proper tankage. Proper tankage denotes tanks which will safely and continuously hold a pressure of at least 16 oz per sq in., which are painted with a heat-reflecting paint, or have insulated walls, and which are as small in diameter as the required volume will economically permit.

Welded-steel production tanks are particularly well adapted for use in pressure systems. They can readily withstand a pressure of several pounds per square inch or a vacuum of a like amount. This is not to be construed as a condemnation of bolted-steel or wood tanks for conservation purposes. Each type of tank has its particular place and job. Both bolted-steel tanks and wood tanks can be obtained which will hold 1 psi. However, the availability of No. 2 steel, proration restrictions, and inexpensive portability have stimulated the manufacture and use of small welded-steel stock tanks.

To keep the temperature within the tank as low as possible, metal tanks should be painted with a heat-reflecting substance. Heretofore, aluminum paint has been used for this purpose. At present, shortage of aluminum forces the use of white or light-colored paints. The thick staves in wood tanks provide their own insulation; however, insulating material is often placed upon the deck of a wood tank to protect both the tank and its contents.

Because vaporization is dependent upon the available surface, it is important that this be kept at a minimum. Therefore, the diameter of the tank should be as small as is consistent with the required volume. Also, it seems reasonable that, if the battery consists of several small-diameter tanks, and runs are made frequently, the losses will be less than they would have been in one large-diameter stock tank with infrequent runs. Therefore, tankage should be fitted to each particular lease, so that production will not have to remain in lease storage for long periods of time.

It has been common practice in the past to allow oil entering a tank to fall from the deck of the tank to the surface of the liquid in the tank. This created a very undesirable agitation which promoted vaporization. In order to minimize this disturbance within the stock tanks, several methods of conveying the oil to the liquid level have been used. These are as follows:

1 By means of a pipe nipple and an elbow immediately below the oil-inlet opening, the stream of oil is deflected against the shell and permitted to slide down the shell in a wide thin stream. In this way, excess or free gas is allowed to escape and the stream quietly enters the body of the liquid in the tank.

2 By means of a sloping trough the oil is conveyed to the bottom of the tank without agitation.

3 The oil-inlet connection can be placed near the bottom of the tank. This method of entry forces all free gas to bubble up through liquid already in the tank, also causing a considerable amount of agitation.

4 A fourth method consists of a sloping pipe which conveys

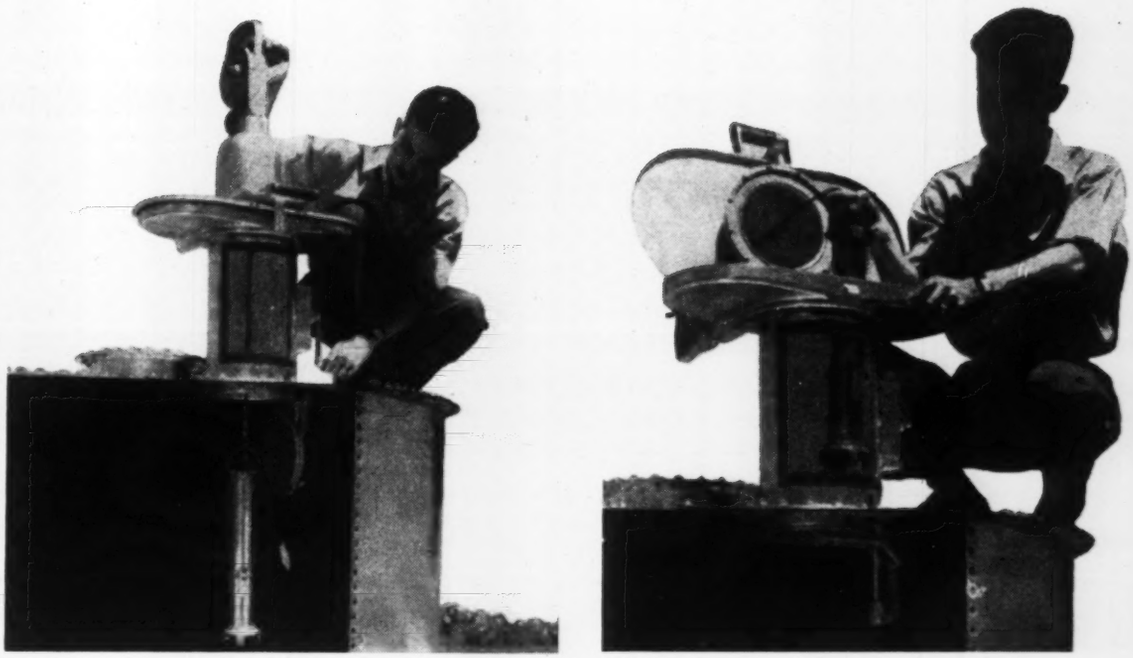

FIG. 2 DEVICES FOR PRESSURE-THIEFING AND GAGING

the oil from the deck to a point about twelve inches from the bot tom of the tank. A standard tee is used on the lower end of the pipe to prevent a continued jetting action of the bottom sediment and water in the bottom of the tank. Two 1-in. holes are cut in the pipe immediately below the tank deck. These holes permit gas to leave at this point rather than travel to the bottom of the tank and agitate the oil as it rises.

The prevention of agitation in stock tanks is undoubtedly a good idea in principle, and there are producers who claim that these devices have effected very noticeable increases in gravity. Downpipes, troughs, or entry of oil at the bottom of the tanks necessitate the use of sampling cocks on the oil-fill line, in order that the operator may determine the bottom sediment and water content of the oil going to stock.

FIG. 3 PRESSURE-GAGING SYSTEM

In maintaining a pressure of 14 to 16 oz in 12-ft-diam welded tanks, constructed of $^3/_{16}$-in. steel plate, it has been found that, when the tank contains only a small amount of oil, the bottom will bulge, raising the shell of the tank a considerable amount, pulling pipe-line connections out of the ground, and doing other damage. In order to prevent distortion of the tank bottom and movement of all lines connected to the tank, a tank tiedown has been devised. This is shown in Fig. 1. Each tiedown consists of two pieces of angle iron, $3 \times 3 \times {}^3/_8 \times 10$ in., which are welded vertically to the shell of the tank just above the bottom. The remainder of the tiedown consists of a 1-in. J-bolt which hooks about a piece of 2-in. pipe, 3 ft long, embedded in the concrete foundation. There are four tiedowns on each 12-ft-diam tank, situated 45 deg from the quarter points. It is possible that these tiedowns would not be required on the smaller-diameter tanks when holding 16 oz pressure or less in the tank.

CLOSED PRESSURE SYSTEMS

Obviously, each time a tank in a pressure system is opened, a considerable quantity of valuable vapors is lost. The goal, therefore, of those who advocate conservation of gravity at tank batteries, is a completely closed system in which the tanks are never opened except for cleaning. This goal has been achieved in only a relatively few isolated and experimental instances. At present, this goal, modified by past practices and present equipment, consists of not opening the tanks more than is absolutely necessary and thus preventing losses by vaporization.

The devices which are being used experimentally to maintain completely closed pressure systems are interesting, because they constitute definite steps toward conservation. None of them has received a general acceptance from the oil industry; however, some have met with local favor. They merit a brief description of their operation because, undoubtedly, some of them will be common tank equipment in future years.

1 One possible solution to the problems involved in maintaining an entirely closed system is the use of pressure-gaging and thiefing locks which have been manufactured by one of the prominent tank companies. When using these devices, it is possible to gage or "thief" a tank in the usual manner without the loss of any of the vapors in the tank. The thief lock attaches to the tank at the common 8-in. round thief-hatch opening and consists of a long thief-hatch bowl and valve on top of a lock chamber. There is a large flapper valve at the bottom of the lock which is manually operated by a crank. A smaller and less expensive lock may be used for gaging only. The tape to be used in these operations is contained in a case which makes a vaportight fit on top of the pressure locks. The case contains a wiper which cleans the tape each time it is reeled in. Figs. 2 and 3 illustrate the operation and appearance of the pressure-thiefing and gaging devices.

2 There are several devices now being manufactured which may be used to indicate the height of oil in the tank without having to employ a gage pole or open the tanks. Most of these devices involve the use of a float in the tank attached to a balance weight outside the tank by a metal tape. The balance weight and the tape are placed in a pipe which is closed to the atmosphere but open to the tank pressure. The piping contains a short nipple of a transparent material through which the oil level may be read from the tape. Fig. 4 illustrates a device of this type. The principal use of this gaging device at the present time is in large storage tanks.

3 Sampling may be done under pressure by sample cocks. The usual practice among oil purchasers is to secure a composite sample of the oil in the tank by mixing a portion of samples taken with an oil thief at three different levels in the tank. This could be accomplished by installing sample cocks at three points on the shell. The pipe on the sampler should extend back into the tank about six inches. This method of sampling has been tried experimentally in the mid-continent area and proved to be quite satisfactory. It is reported that this method of sampling is quite common in California. A sampling tube or pipe might also be used to check the bottom-sediment level if one were placed 4 in. below the pipe-line connection.

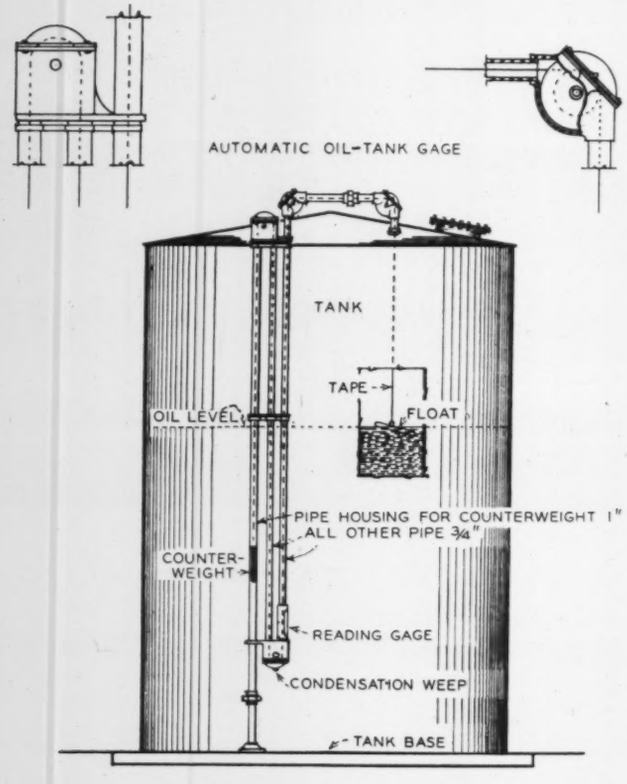

FIG. 4 AUTOMATIC OIL-TANK GAGE

4 It would be entirely possible to gage some stock tanks by means of gage glasses. However, it may be that this would not be feasible when handling the very low-gravity crudes. Such glasses would require protection against breakage, for a carelessly broken one would allow oil to leak out of the tank onto the grade and create a dangerous fire hazard. It would also be necessary to connect the glasses in such a manner that they could be easily cleaned.

In addition to the reduction of evaporation losses, there are two benefits to be derived from completely closed pressure systems:

1 There will be a reduction of the hazards attendant to gaging tanks in sour-gas areas. There will be no opportunity for the fatal, or near-fatal, accidents which have been caused by breathing toxic vapors.

2 A completely closed pressure system will do much to prevent corrosion of the inner surfaces of metal tanks. There are many examples to be had in which there is no corrosion to be found in the wells, lead lines, or separators, yet the tankage is severely corroded. The tanks are the first place in which the produced fluids are exposed to the atmosphere. If oxygen is excluded from contact with the fluid in the tank, the rate of corrosion should be drastically reduced. Thus, the closed pressure systems will be the means of extending the life of steel production tanks. In this connection, it is especially important that thief hatches be closed while oil is being pumped out of a tank. As the oil is drawn out of the tank, air would be drawn into the tank if the thief hatch has been left in an open position. Such a procedure encourages corrosion and may noticeably reduce the A.P.I. gravity of the sales.

DESIGN OF THIEF HATCH

One of the most essential pieces of auxiliary tank equipment is a reliable thief hatch; one which has been tested and can be depended upon to open at the stated pressure and vacuum, no more and no less; one that has large pressure- and vacuum-release openings in order to protect the tank from excess pressures; and one whose gaskets are oil-resistant and can undergo thousands of pressure and vacuum releases without damage. The gaskets and springs should be readily replaceable. Fig. 5 shows a thief hatch which has these desirable qualities. It is a spring-loaded latch-type 8-in-opening thief hatch, with an 8 × 22-in. bowl. It is now in common use with welded-steel tanks. All nuts and screws are large enough to be durable. The gaskets are readily replaceable and the springs can be removed by merely depressing and turning the pressure disk through 90 deg. This general type of hatch is also manufactured in a dead-weight variety.

BACK-PRESSURE VALVE

The second piece of equipment necessary to a pressure system is a back-pressure valve for use on the manifolded vent or equalizing line which is connected into the tops of all the tanks. These valves can either be placed in the vent line after the last stock tank, or on the end of the vent line as a stack valve. They are generally weight-loaded, should have a large area through the opening, and should be accessible for cleaning from the ground or tank deck. It is believed that valves, thief hatches, and back-pressure valves are more satisfactory when equipped with oil-resistant rubber gaskets. The reason for such a choice is that any string, small amount of dirt, or any minute foreign material will probably cause leakage through a metal-to-metal seat, while a rubber gasket can maintain pres-

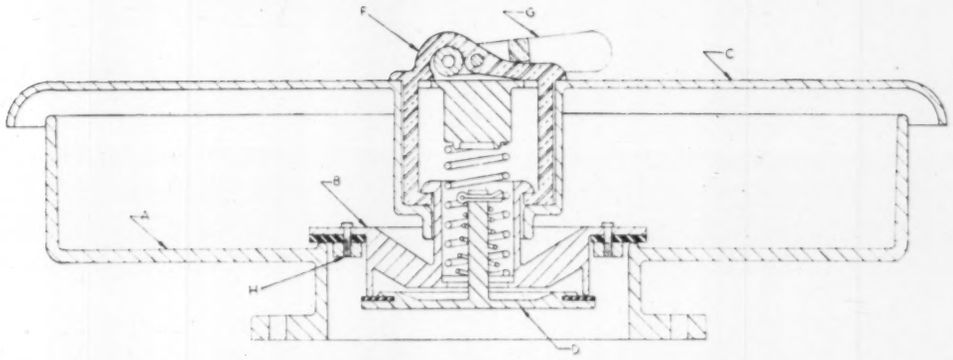

FIG. 5 LATCH-TYPE THIEF HATCH WITH VACUUM AND PRESSURE RELEASE

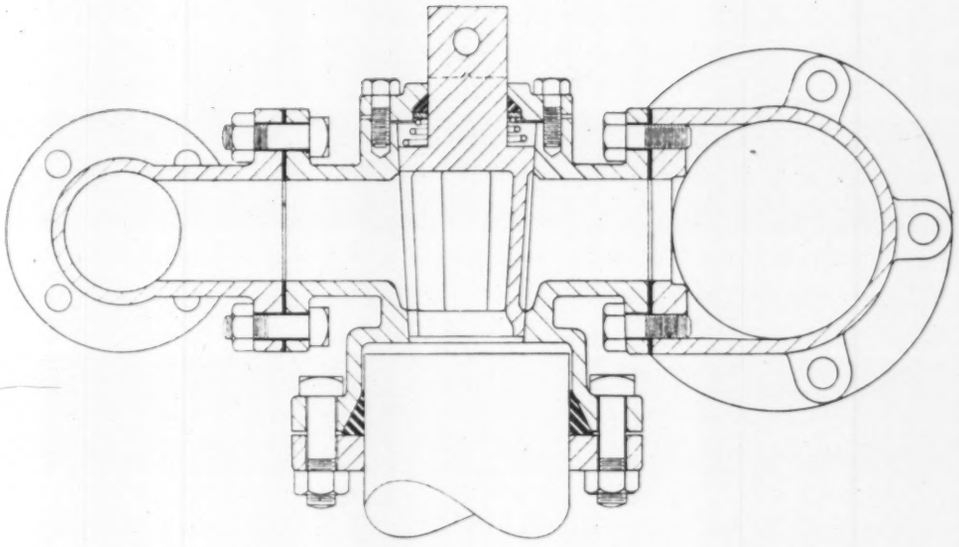

FIG. 6 SPECIAL THREE-WAY PLUG VALVE WITH 2-IN. AND 4-IN. CONNECTIONS

sure even though a small amount of foreign material is on the seat.

OPENING TANKS SEPARATELY IN A PRESSURE SYSTEM

The third requirement for successful operation of a pressure system for a tank battery is some method of opening one tank without losing the valuable vapors from all of the other tanks. Placing a gate or plug valve in the tank riser to the vent line would be the most obvious means of doing this. Another device which is being successfully marketed consists of the use of a check valve in the tank-vent riser. When the thief hatch is closed, a lever holds this check in an open position and allows the tank to breathe as need be, in conjunction with the other tanks, through the medium of the common vent line. This same method has been incorporated in a thief hatch which has the vent opening and check-valve seat cast as a part of the thief-hatch base.

These methods effectively remove one tank from the vent system and prevent loss of vapors from any but the one tank. However, they lack one important safety feature. They allow gas from the tank to be discharged directly into the operator's face when the thief hatch is opened. This has cost the lives of several men and has caused numerous near-fatal accidents. For this reason, a system has been designed whereby this gas is discharged at some distance from the thief hatch.

The original system which fulfills this requirement consisted of a standard three-way stopcock placed in the tank vent-line riser. The remote-control operating handle was hinged to rest upon the hatch in such a way that this handle must be pushed back in order that the hatch might be opened. Thus, when the thief hatch was closed, the three-way stopcock was open in a through position to the regular vent line on whose outer end was a back-pressure valve. When the handle at the thief hatch was operated, the tank was taken out of the pressure system and, at the same time, the gas was vented through the side opening in the three-way cock. Gas was then carried completely away from the tanks by a blowoff line.

The eventual outcome of this development was a special plug valve manufactured for this express purpose. Fig. 6 shows this valve in detail. In operation, gas passes through the hollow plug and through one of two side openings either to the blow-off line or to the regular vent line. The tees on either side of the cutoff valve are flanged, and the running openings are equipped with slip-on flanges and rubbers which require no threads. In operation, it is very similar to the three-way stopcock. When the hatch is closed and the handle is down the

valve is open from the tank into the regular vent line. When the lever is raised, the tank is shut off from the other tanks and opened into the blowoff line. Thus, when the hatch is opened, the gas has already been vented and does not strike the operator in the face. Fig. 7 shows an installation using this valve. This particular piping hookup for conservation purposes is now successfully operating on numerous tank batteries in Oklahoma and Kansas.

As it is seldom necessary to open the receiving tank, the complete pressure-control system does not extend to this tank. However, it is connected to the common vent line and has a thief hatch similar to those on the stock tanks.

OTHER CONSERVATION DEVICES

In addition to the tank equipment which is necessary to effect a conservation of gravity, there are other devices which may be utilized to reduce to a minimum the number of times a tank must be opened. Two of these are described as follows:

Automatic Fill Valves. Several types of fill valves have been manufactured. These valves are manually set in the open position and, when the tank has filled to the desired level, they are tripped by a float. A spring-loaded valve shuts off the stream of oil entering the tank which is full and directs it into the next tank. These valves operate satisfactorily in clean noncorrosive oils; however, if the fluid be corrosive, or has a high paraffin content, trouble may be experienced. The use of these valves saves pumper labor in that the pumper need not be at the battery in order to "top out" a tank.

Overflow Lines. Overflow lines are designed to accomplish the same purpose as do fill valves. The manner in which they are connected divides them into two groups, i.e., those which are connected only between adjacent tanks, and those in which all tanks are connected to a common line. In the first type, it is possible only to flow oil from any one tank to an adjacent tank. In the latter type, oil may be directed from any one stock tank to any other stock tank. In order to enable the operator to open one tank without losing the valuable vapors from the other tanks, it is necessary that these lines be equipped with valves or a liquid seal. A locking valve is generally required by the pipe-line companies.

Overflow lines reduce pumper labor and also the number of times a thief hatch must be opened. An illustration of an overflow line in one horizontal plane is shown in Fig. 7.

CO-OPERATION OF PERSONNEL NECESSARY

No matter what equipment might be installed in tank batteries, it will not be successful unless it has been thoroughly "sold" to the field personnel. Until the men who must operate the equipment are convinced of the worth of conservation of gravity and of the utilitarian features of the equipment installed, it will not operate successfully. They must also be well acquainted with the operation, maintenance, and repairs which may be required. One of the most convincing proofs to offer in evidence for conservation of gravity is the record of corrected A.P.I. gravity of oil sold before and after installation of pressure equipment. If this cannot be obtained, comparison can be made between the gravity of a sample of oil, cold-treated at the well head, and the gravity of the sales.

CONCLUSION

In brief, what the author has endeavored to say is this. Conservation of our natural resources is important, especially so at this time. The losses sustained in handling this nation's oil represent an enormous sum of money. A small operator or the owners of a small lease can well afford to take part in a gravity-conservation program. If only for a selfish motive, all producers should attempt to prevent evaporation losses at lease-tank batteries for the following reasons:

1 There are many tank batteries at which the A.P.I. gravity of the oil sold could be raised 1 deg. Additional revenue amounting to nearly 5 per cent would result.

2 The corrosion of metal tanks should be greatly reduced by the exclusion of oxygen from the tanks.

3 The hazards attendant to gaging the tanks would be reduced. This would eliminate expensive accidents attributed to breathing toxic vapors.

4 Devices such as overflow lines and automatic fill valves reduce pumper labor as well as promote conservation of gravity.

The goal of all those interested in gravity conservation is a system which is entirely closed, in which the oil is continually held under a slight pressure. However, until this goal is achieved, there are practical methods of effecting conservation of gravity at lease-tank batteries. Finally, like many other ideas, it must be sold to those who are to use the equipment before actual conservation of gravity can be effected.

FIG. 7 INSTALLATION SHOWING VAPOR-CONTROL SYSTEM AND OVERFLOW LINE

QUALITY CONTROL *With* SAMPLING INSPECTION

By C. S. BARRETT

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APPRECIATION of the utility of statistics and statistical methods in the general field of engineering and manufacturing has made considerable advance during the last several years. Unfortunately, there are some engineers and organization executives who are still prejudiced against mathematical statistics in any form, preferring to rely on "common sense." Such people overlook the fact that statistics has been defined as "common sense reduced to calculation."

EVOLUTION OF QUALITY CONTROL

Quality control in a broad sense has been operating in the manufacturing process since the industrial revolution, late in the eighteenth century. However, quality control based on statistical concepts is of comparatively recent origin. The subjective qualitative evaluation of quality of a generation ago has been supplanted in some progressive organizations by objective quantitative forms of measurement.

The technology of mass production by its very nature depends upon the interchangeability of parts, that is, any one of a mass of parts coming from one manufacturing process must fit together with any one of many parts coming from some other manufacturing process. It has been realized for a long time that the Newtonian concept of exactness simply will not work when applied to modern mass production engaged in the fabrication of interchangeable piece parts. Once this condition had been recognized, it was more or less a natural step to the use of actual tolerance limits now used almost universally.

Any manufacturing process may be expected to produce parts whose characteristics will vary about some average value. The production-engineer's problem is to control these variations within a range such that the percentage of defects is at an economical level. Statistical control is said to exist when the variations in the observed values are produced by a constant system of chance causes. By means of statistical techniques the engineer is able to establish numerical fixed limits outside of which a purely chance variation becomes highly improbable. Any appreciable proportion of the values falling outside of these limits could be said with confidence to be due to some assignable cause which it is expected could be identified and corrected.

When manufactured products were made more or less by hand, as it were, each workman was looked upon as a craftsman, and as such took full responsibility for the quality of his product. In this type of manufacturing process almost a hundred per cent or detailed inspection of all readily observable characteristics was obtained. With our present scheme of mass production by automatic machines and the modern concept of tolerance limits, inspection of every part becomes impracticable. Therefore sampling in some form is practiced more or less universally in all large production units consciously or unconsciously. However, certain characteristics in the completed product may be detailed 100 per cent.

Contributed by the Management Division and presented at the Annual Meeting, New York, N. Y., December 1–5, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

SAMPLING PROCEDURE

In giving consideration to the establishment of any sampling procedure the following fundamentals must be kept in mind. The sample must give a reasonably accurate picture of the whole from the result of inspections of a few. There exists the chance that unsatisfactory material may be accepted, "consumer's risk," and the chance that good parts may be rejected, "producer's risk." In any type of sampling there is always a certain degree of uncertainty. The most that can be said is that, in the absence of assignable causes, the characteristic of the sample will represent within certain limits the characteristic of the universe from which it was taken a certain percentage of the time. If the characteristics of a lot are to be predicted with any reasonable degree of accuracy from results of sampling the lot, something should be known of the general characteristics of the universe of which the lot is a part. Furthermore the method of selecting the sample must be carefully predetermined, that is, it must be truly representative and not just haphazard. As a practical example, if a lot is made up of products from five different machines care must be taken that the product from each of these machines is represented in the sample; as otherwise one machine could be producing all defective parts and yet no indication of this condition would be given.

There is one field where sampling is not a question of choice but is imperative. In the field of destructive tests it is obviously impractical to test all the product. The operations of fuses, for example, certainly could not be tested 100 per cent as then there would be no product left to deliver.

Tests or measures of quality may be founded on inspection by attributes or inspection by variables. In the case of attributes a quality characteristic is inspected on a "go, no-go" basis. The part, unit of apparatus, assembly, or material either meets a specification requirement or it fails to meet the requirement. In the latter instance the part is considered a "defective." Variables inspection on the other hand involves a measurement of the quality characteristic of each part in the sample and a record on some continuous scale of measurement. Suppose that the specification requirement for the diameter of a shaft is 1 in. ± 0.01 in. Attribute inspection would reveal the number of shafts with diameters between the limits of 0.99 in. and 1.01 in., and the number under or over these limits, respectively. Variables inspection would reveal the exact diameter of each shaft inspected, for example, 0.9984 in., 1.0002 in., 0.9994 in., etc.

There have been many unique plans of sampling developed and put into use employing inspection by attributes. Each plan differs from the others depending upon the type of protection desired, the nature of the product, the process average per cent defective, the producer-consumer relationships, and many other factors. The field of attribute inspection has been covered by many publications in recent years.

A recent publication[1] by Messrs. Dodge and Romig of the Bell Telephone Laboratories admirably portrays single- and double-sampling attribute-inspection procedures, types of quality protection afforded, mathematical development of the sampling tables, and over forty ready-made sampling inspection tables suitable for attribute-sampling inspections. We in the Bell System look upon this paper as "the last word," in so far as sampling by attributes is concerned. The sampling tables contained therein are in daily use in the inspections of completed material and the countless parts which make up Bell telephones and associated central-office equipment.

INSPECTION BY VARIABLES

Variables methods seem to lend themselves admirably to inspection requiring destructive tests. The results of destructive tests obtained by variables inspections will range about some average value. For instance, let us assume that a certain type of steel may be expected to have an ultimate tensile strength of 45,000 psi. A series of samples will not break at exactly this value but rather at lesser or greater values. However, it is reasonable to expect that the series of measurements will average about 45,000 psi. From such tests on samples selected from a statistically controlled universe, certain parameters or characteristics of the lot can be calculated. The two most commonly used are the average or central tendency referred to as $\bar{X}$ which is analogous to the center of gravity in mechanics, and the standard deviation σ, a measure of the spread of the individual values about their average which is comparable to the radius of gyration.

It has been quite generally accepted that considerably fewer parts may be inspected on a variables basis than on the basis of attributes for the same degree of belief in the action taken with respect to the criteria usually used. Obviously in the case of destructive tests this is an advantage of great importance. The inspection by variables has another advantage over that of attributes in that trends may be much more readily observed. Recalling that the attribute-inspection results merely indicate the percentage of the product which fails to meet a specification requirement, if 100 per cent of the product meets the requirement day after day or month after month, the data cannot indicate how well the requirement is met or when the danger of approach to the specification limit is imminent. Furthermore the results by attributes are extremely unreliable in instances where the product must be controlled at a very small per cent defective, say, 1 defect in 10,000 parts, unless a relatively large sample is inspected. Again in the case of destructive tests this would be costly. Variables inspection seems to be the answer to some of these problems.

In order to illustrate some further aspects of quality control based on variables-sampling inspections, let us consider the development of such a sampling scheme as it was found to be functioning in an actual situation. First, however, it will be necessary to present some historical background. The quality of welding of precious-metal contacts to springs for relays and other telephone equipment is measured against an engineering requirement that a contact shall withstand a shear test of 7 lb. In most relay springs used in telephone equipment contacts are made from a bimetal tape consisting of a precious-metal cap roll-welded to a pure-nickel base. The contacts are cut from this bimetal tape and welded to nickel-silver springs. The average number of contacts in a single assembled relay is about 25. In the case of relay springs the contact-welding job is considered satisfactory if not more than 1 weld in 10,000 fails to meet the specified shear-test requirement of 7 lb. The method of controlling the quality at this desired level is the example to be discussed here.

[1] "Single Sampling and Double Sampling Inspection Tables," by H. F. Dodge and H. G. Romig, *Bell System Technical Journal*, vol. 20, Jan., 1941, pp. 1–61.

WELDING CONTACTS FOR RELAY SPRINGS

Prior to experiencing field difficulties no formal sampling for this requirement was employed. The supervisor made regular observations of the machines in operation and a roving inspector made an occasional test of the strength of the welds. However, adequate safeguards were not set up and reports from the field clearly showed that better control of these operations would have to be provided.

When the inspection staff realized that the quality had to be maintained at such a high level, not more than 1 failure in 10,000 welds, they were not able to find any of their regular sampling tables that seemed to meet the need. Faced with the necessity that immediate improvement was demanded, the inspection supervisors reached the decision that the product must be inspected 100 per cent.

The practice of detailing the product soon proved to be questionable. In the first place the procedure was very costly in comparison to the value of the parts. Also there was the rather serious question of damaging some of the contacts in making the tests especially in those cases where the welds were capable of withstanding only a few pounds over the requirement. Another important consideration which is rather intangible and difficult to evaluate is the human-equation factor inherent in the process of sorting out the defects from large quantities of the product where quality must be maintained at such a high level. There are many engineers who are strong in their belief that it is not humanly possible to attain this degree of accuracy in routine inspection over long periods of time. Attempts to make this check a machine operation were abandoned when it was found that any tests for the strength of weld introduced the element of damage to the contacts and tended to weaken the welds.

At this point the statistical organization was consulted and requested to work out a sampling plan that would replace the detailed inspection and still give assurance that a satisfactory quality was being maintained. In most sampling schemes the assumption can be made that if a lot of product does not measure up to the sampling criteria the product can be detailed and the defectives removed. In this case, however, the tests were at least semidestructive and the problem of sampling had to be approached accordingly. The remedy for the trouble appeared to require a "process-control" plan at the welding machines which would assure that only satisfactory welds were made. This in turn necessitated improved gaging equipment and a study of the product to show the effect of the various controllable factors on the strength of weld and the amount of control over these variations which could be exercised.

It was decided early in the investigation that attribute checks would have to be replaced by variables measurements which would of course require pushing the contacts from the springs and recording the pressure at which the welds broke away. As a result of the measurements made on the welds produced by each machine and each operator, changes were instituted in the tools and techniques until the average strength of weld for each machine and each operator was increased to a point considerably above the engineering requirement.

FACTORS IN CONTROLLING WELDING PROCESS

Factors which might be expected to contribute to the variations in strength of weld were studied to determine the importance of each in controlling the welding process. Experiments were made to determine the variation of strength of weld with (1) welding current, (2) surface condition of the springs,

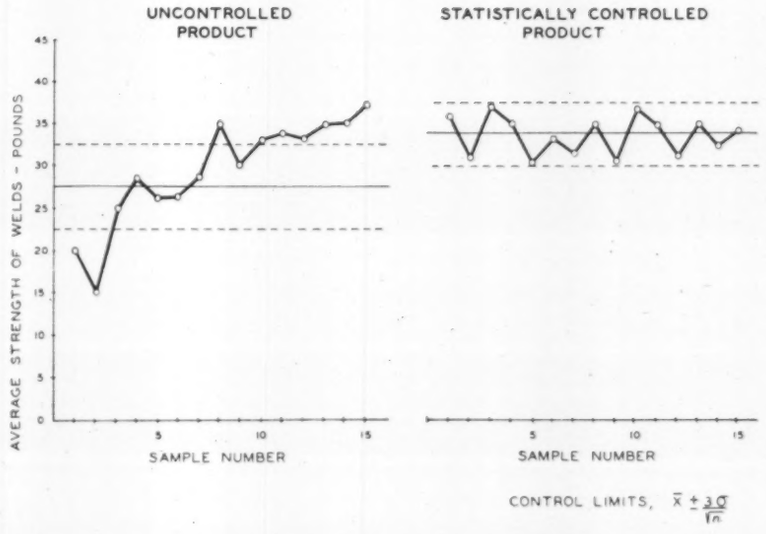

FIG. 1 CONTROL CHARTS FOR AVERAGE $\bar{X}$

whether clean or contaminated by grease, dirt, and perspiration, (3) the condition of the welding tape, whether clean or coated with chloride, sulphide, or perspiration, (4) the contour of the projection or "bead" on the welding tape, whether normal or malformed, and (5) the mechanical pressure applied.

1 Variations in welding current were found to make a significant difference in the strength of weld. The average strength was greater for higher values of current than for low values. However, when the welding current was set too high, flashes and burning became noticeable.

2 To test for the effect of contamination by grease, dirt, and perspiration on the surface of the springs, both clean and contaminated springs were welded, while other conditions were maintained the same as those which resulted in satisfactory welds. In general the inspections show lower strength for the contaminated springs although not as much as was expected. Although the effect of contamination on the quality of welding was found to be relatively small in the case of the nickel-silver relay springs, as noted previously, in other apparatus where low-resistance contacts such as silver are welded to a low-resistance base such as brass, the surface conditions of the material being welded become a very important factor in controlling the quality of the welding. It is necessary to exercise special precautions to eliminate variations in the surface resistance of the materials being welded.

3 To test for the effect of dirty welding tape on strength, a length of tape was secured and contaminated in alternate measured sections with perspiration and dirt on hands and by forming a chloride and a sulphide on the tape between lengths of normal tape. The tape was then welded and the welds tested. The contaminated sections of tape produced lower-strength welds, but only for sulphide-contaminated tapes were the strengths significantly lower. Here again it must be remembered that the materials under consideration were nickel-base bimetal tape welded to nickel-silver springs. If the contact tape and the spring metal are of lower resistance and more easily corroded, it is to be expected that the effect of contamination on the quality will be much greater.

4 The effect of variations in the shape of the precious-metal tape was also investigated. While for the properly shaped tape the welds were the strongest, the usual variations in the shape did not alter significantly the weld strength.

5 A series of experiments was also performed to test the effect of the mechanical pressure applied between the tape and the spring during the welding process. It was discovered that for the minimum pressure at which the machines would operate the welds were the strongest, although at this minimum pressure excessive arcing and burning between the electrode and the contact metal occurred. Consequently it was decided to select the pressure which would produce the strongest weld consistent with minimum burning of the electrode.

The next step was to study the variations in the results obtained from each machine, each operation, each lot of material, and the like. The results were studied statistically, variations not attributable to chance causes were analyzed, and corrective measures were taken to eliminate the causes of variations, Fig. 1. In brief, every attempt was made to attain statistical control of the product at a level which provided a safe margin between the strength of weld of the product and the engineering requirement, before a sampling plan was placed in opertaion. After corrective action had been taken as a result of the investigations to determine and eliminate causes for assignable variations, it was found that the process was capable of producing satisfactory welds, with a standard deviation of 6.3 lb and an average strength of 34 lb or higher, depending upon the thickness of the parts welded, the adjustment of electrode pressure, current tap, etc.

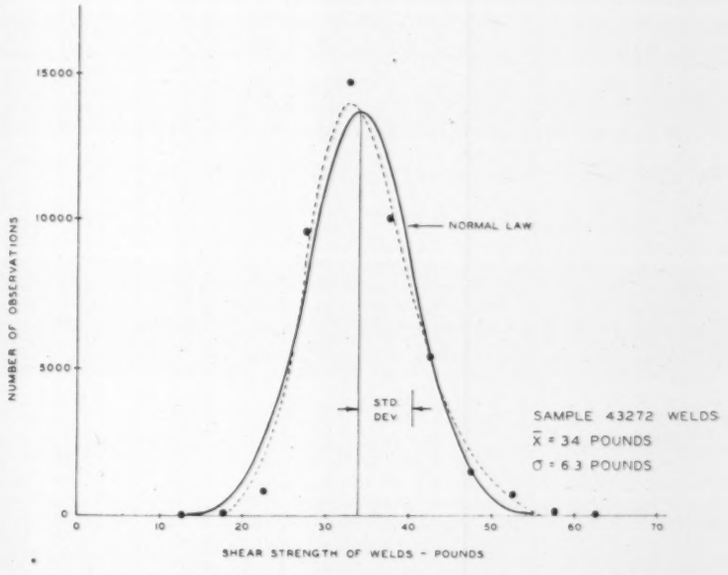

FIG. 2 "CONTROLLED-PRODUCT" DISTRIBUTION OF WELDS

Fig. 2 shows a "controlled-product" distribution of welds, with an average of 34 lb and a standard deviation of 6.3 lb. Under these conditions, the normal law probability theory predicts that less than one weld in 10,000 will fail on a 7-lb test. Actually, as indicated by the dotted curve, the distribution is somewhat skewed so that an even smaller proportion would be expected to fail on this test. Experience in this case has shown that the prediction is substantially fulfilled so long as the product remains controlled.

In Fig. 2, it will be noted that the lower three σ value is approximately 15 lb. On this basis, the sampling setup

HW 296-D (9-40) DAILY RECORD OF TESTS ON CONTACT SPRINGS

Date Manufactured 11-3-41
Operating Dept. 1492-1 Code or P.P. No. 123789
Machine No. 1 Contact Metal 987
Lot Size 14400 Contacts

CELLS	LBS.	STRENGTH OF WELD BY HOURLY PERIODS 1st	2nd	3rd	4th	5th	6th	7th	8th	REMARKS
Oper. No.										
1	0-4									
2	5-9									
3	10-14									
4	15-19									
5	20-24	//								
6	25-29									
7	30-34		///			𝍸 ///	𝍸 ////			
8	35-39	𝍸 ///	////	𝍸 𝍸	////	////	/			
9	40-44		𝍸		/		////			
10	45-49									
11	50-54			////	𝍸					
12	55-59									
13	60-64									
14	65-69									
15	70-74									
16	OVER 74									
Gaging										
Visual										
Nature of Machine Adjustment										
By Mach. Setter										

FIG. 3 RECORD OF TESTS ON CONTACT SPRINGS

assumes that the strength-test results falling below 15 lb indicate some significant change in the process, and a product produced under such conditions is not used. As an additional safeguard, it was decided to readjust the welding machines whenever a weld was observed with a shear strength of less than 25 lb. This value was selected with the object of striking a balance between economical operation and maximum assurance of the production of satisfactory welds.

SAMPLING PROCEDURE

The stage was then set to determine a sampling plan which would assure that this control was continued. If everything went well, the process would automatically produce the quality at a satisfactory level. After several preliminary plans had been tried out the following sampling procedure was inaugurated:

The machine setter adjusts the machine until welds are obtained having a shear strength above 25 lb. The machine is then turned over to the operator who submits to the inspector the first contact welded. The inspector checks the strength of weld and records the value in an appropriate cell, Fig. 3.

The cells are arranged in widths of 5 lb from zero to 75 lb. The inspector then tests every two-hundredth weld from each operator and records the "breaking or shearing value." If a weld fails below 25 lb but above 15 lb, the machine is immediately stopped and readjusted until it is producing welds with a strength over 25 lb. The 200 parts produced between this test and the previous one are passed. If a weld is found which fails below 15 lb, the machine is stopped and adjusted again to produce parts above the "machine minimum limit." However, all the 200 preceding parts are stripped of their contacts and rewelded.

The daily variables results are sent to the tabulating department where they are summarized on a weekly and monthly basis. These summaries are then returned to the inspection department where they are used as a tool for supervising and taking corrective action whenever a tendency exists toward poor quality.

The sampling scheme thus furnishes inspection information which serves, when the quality is running good, as a verification of process control and provides a screening agent when quality is jeopardized. This sampling scheme for the variables inspection of the strength of weld specifies the inspection of 150 welds from the average daily output of 30,000 welds. The actual inspection results have indicated an average strength of weld of about 34 lb with a standard deviation of approximately 6.3 lb. Assuming a normal distribution, when the minimum of 7 lb is considered in relation to these values we find by the formula $t = \frac{\bar{X} - L}{\sigma}$ where L equals the engineering limit of 7 lb that $t = 4.3$.

By referring to normal law probability tables and recalling that the distribution has a positive skewness, Fig. 2, it may be concluded that the probability of occurrence of a weld strength lower than 7 lb is much less than 1 in 10,000 as long as statistical control is maintained.

Fig. 4, which is typical of charts described by the American Standards Association,[2] shows how well the product has been controlled over a recent period. While there are some points above the upper limit line which indicate lack of statistical control, these points are in the direction of a better product. It has not been considered economical to attempt to isolate the causes of these variations.

The fact should not be overlooked that the terms "assignable" and "chance" are only relative. Not only may some of the "chance" causes be assigned as a result of further investigation and the accumulation of additional knowledge, but others which could be isolated and corrected may be left unidentified because the cost of the additional investigation would not be justified, as illustrated in Fig. 4. In other words, we reach a point at which the "law of diminishing returns" makes the necessary effort to produce additional control uneconomical.

The relationship between the technical and the statistical approach to the problem of quality control seems evident. A thorough knowledge of production processes coupled with sound judgment is required in collecting and grouping the original data. A statistical "sense" is then needed for analyzing the grouped data, and finally technical skill is required for isolating and correcting the causes of the difficulties.

[2] "Control Chart Method of Analyzing Data," A.S.A. Standard Z1.2–1941.

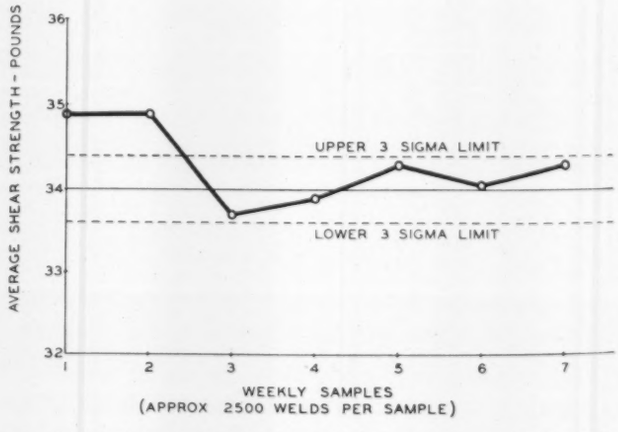

FIG. 4 SHEAR STRENGTH OF WELDS BETWEEN PRECIOUS-METAL CONTACTS AND NICKEL-SILVER SPRINGS

The Principal FUNCTION *of* PULVERIZED-COAL BURNERS

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THE principal function of pulverized-coal burners is to distribute fuel and air evenly in a furnace. This paper discusses methods and problems involved in obtaining this even distribution in the furnace. The vertical, the horizontal, and the tangential methods of firing are considered.

Even distribution of fuel and air means that every square foot of the cross section of the stream of the burning mixture in the furnace gets its share of fuel and air, and this uniformity of distribution is maintained along the full length of the path of the burning mixture through the furnace. If the distribution is not uniform certain parts of the furnace get too much fuel and too little air, and other parts of the furnace get too much air and too little fuel. In the parts of the furnace which receive too much fuel, the temperature is high, and there may be a heavy deposit of slag in the furnace. There are also likely to be heavy deposits of slag on the boiler tubes and superheater, where the products of combustion from the excess fuel enter the boiler. Lack of air in one part of the stream causes incomplete combustion, even though high over-all excess air is maintained at the furnace outlet.

VERTICAL FIRING

In a vertically fired furnace, a number of burners are located in the arch, and the mixture of fuel and primary air is blown downward in parallel streams. Some air is admitted through the burners around the fuel nozzles, also in a downward direction. The remainder of the air, necessary for complete combustion, is admitted through air ports in the front furnace wall in a horizontal direction. The burners are evenly spaced across the furnace, and if each burner gets an even share of the fuel and air the fuel distribution across the furnace is even. Such even distribution of fuel across the furnace can be particularly well obtained with the storage system of firing where the amount of coal delivered to each burner can be easily adjusted by the speed of the feeder. The air ports for the admission of secondary air are also evenly spaced across the furnace and can be so operated as to result in uniform distribution of the secondary air across the furnace. Vertical firing, under such conditions, offers full possibility of even distribution of fuel and air to the furnace. It is probable that this was the principal reason for the success of vertical firing during the early development of pulverized-coal application to steam boilers. The design of this firing was simple because it followed simple fundamental principles and was less affected by incidental factors which occasionally crept into the design of equipment. The parallel flow of the fuel streams through the furnace caused less impingement of flame on furnace walls. Such impingement was very undesirable in the early stages of pulverized-fuel firing, because the furnaces were refractory-lined, and flame impingement caused rapid wasting away of this refractory lining.

Later, vertical firing was adapted to direct-firing systems. In such applications, the stream of fuel from each mill had to be divided into two, three, or four streams, one stream for each burner. The division of the stream may be done at the mill or anywhere in the fuel pipe between the mill and the burners. If one stream is divided into four, the division is usually made in two steps; the mill stream is divided in two, and then each of the two streams is again divided into two. The even distribution of the coal to the furnace then depends upon the nicety of the division of the stream.

DIVISION OF COAL STREAMS

Accurate division of a coal-and-air stream is difficult to obtain. If the division is made by a simple Y-shaped connection, one branch is likely to get most of the coal, and the other most of the air. A much better division is obtained by providing the Y-connection with riffle plates, which divide the one stream into a large even number of small streams, and collecting the even-numbered sections into one branch and the odd-numbered sections into the other branch. The riffle divider works on the same principle as the riffle used for reducing the size of a sample of coal.

In the bin system, the pulverized-coal bins and feeders were usually located above the burner arch, and the pipes, taking the fuel from the feeders to the burners, were nearly straight, the fuel mixture flowing downward. There was much less chance of concentrating the coal on one side of the coal pipe, and the fuel streams issuing from the burners were very nearly parallel. In the direct-firing system, the mills are usually located on the ground floor, so that the pipes leading to the burners must turn 180 deg. In addition to these turns, there are usually side offsets. As a result, the coal may be concentrated

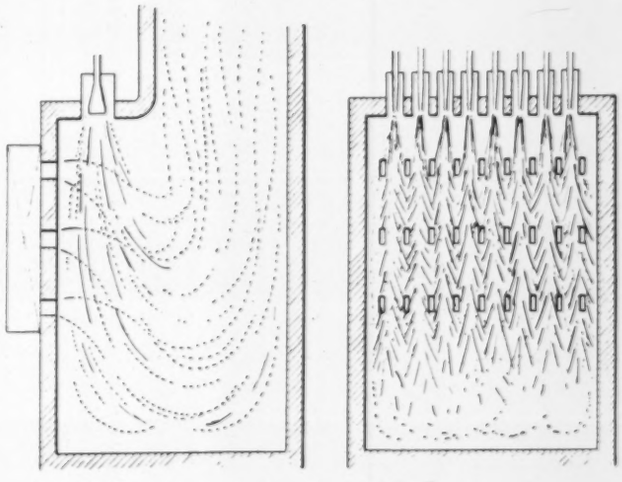

FIG. 1 VERTICAL FIRING

(A mixture of coal and primary air is fired in parallel streams downward. Distribution of fuel is obtained by burners evenly spaced across furnace. Secondary air is supplied in horizontal streams, also evenly spaced across furnace.)

Contributed by the Fuels Division and presented at the Annual Meeting, New York, N. Y., December 1–5, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

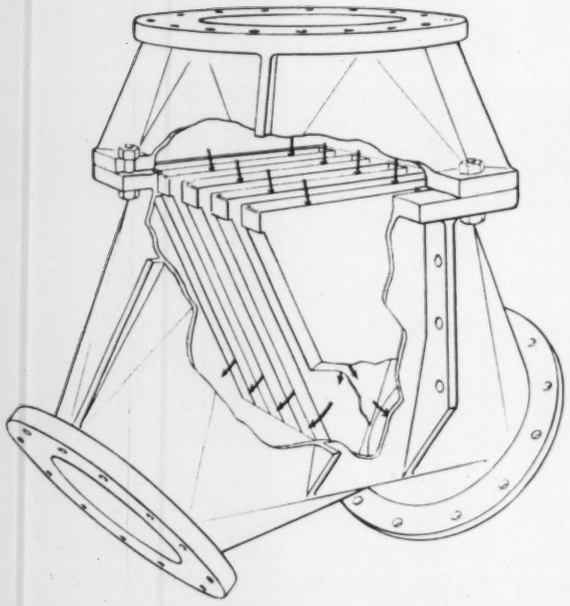

FIG. 2 RIFFLE DIVIDER
(Device for dividing one stream of pulverized coal into two equal streams. Division plates are about 1 in. apart.)

on one side of the coal stream, issuing from the burner nozzle into the furnace, depending upon the summary effect of the turns and offsets in the fuel pipes. The one-sidedness of the fuel streams may affect the distribution of the coal in the furnace, and special deflectors may have to be inserted into the fuel pipes just ahead of the coal nozzle to obtain uniform distribution at the nozzle.

HORIZONTAL FIRING

The horizontal-firing system was developed when the direct-firing system came into use. At that time, there was a general demand for a simple and inexpensive design. The elimination of the pulverized-coal bins and feeders simplified the plant design and reduced the cost of pulverized-coal installations. The introduction of horizontal firing simplified the furnace design and reduced its cost by the elimination of the burner arch used with vertical firing. In horizontal firing, burners with more turbulent flow are used. This greater turbulence makes it possible to distribute coal from each burner over a larger part of the furnace. Therefore, horizontal firing offers possibilities of reducing the number of burners to the furnace. This smaller number of burners was desirable because it simplified the fuel piping. A furnace which with vertical firing required eight burners could be equipped with four or even two horizontal burners. Instead of eight fuel pipes that were necessary with vertical firing, only four or two coal pipes were needed for horizontal firing. The division of the pulverized-coal-fuel streams was made simpler because, instead of dividing the stream from one mill into four streams to supply four vertical burners, it was only necessary to divide the stream into two streams for two horizontal burners. In smaller units with small mills, one burner to a mill made a simple and efficient arrangement. The chances of obtaining equal division of coal from one to two streams are much better than they are in dividing from one to four streams.

The horizontal pulverized-coal burner followed the design of the conventional oil burners. The fuel and air are given rotative movement as they pass through the burner. This rotative movement gives the fuel and air turbulence which bushes out the stream into a flat cone upon the entrance of the mixture into the furnace. When the fire of a well designed and operated horizontal burner is viewed through an observation door in the rear wall, the flame appears to be of the shape of a sunflower, with the flame seeming to radiate from the center of the burner, like the petals of the sunflower.

The rotation of the fuel stream is obtained by a volute entrance into the fuel nozzle or by the use of a propeller-shaped paddle wheel within the nozzle. The rotation of the secondary air is obtained by adjustable vanes in the burner body.

The horizontal method of firing has advantages which are obvious, but in some cases it is rather difficult to realize these advantages fully. The horizontal burner is sensitive not only to the adjustment of its own parts but also to the design of the fuel piping bringing the pulverized coal from the mill to the burner. Even distribution of fuel and air to the furnace with the horizontal burner is more difficult than it is with vertical firing. In the first place there are fewer burners, and therefore the streams of fuel entering the furnace are larger. The path of the burning mixture between the mouth of the burner and the boiler is usually shorter than it is with vertical firing. Consequently the distribution of coal and air across the entire cross section of the moving stream of burning mixture from the burner wall to the boiler must be accomplished in a short distance from the burner. Because there are few burners in the furnace, the coal from each burner must be distributed over a large area. To distribute this coal over such a large area in a short distance from the burner is a complicated problem. This can be illustrated best by studying a specific example.

HORIZONTAL FIRING WITH ONE BURNER

Let us take a unit having a furnace 10 ft wide and 15 ft high, equipped with one horizontal burner. The burning mixture moves from the front of the burner wall to the boiler, and the fuel and air should be distributed uniformly across this width of 10 ft and height of 15 ft as close to the burner as possible. The cross-sectional area of the fuel-nozzle tip is about half a sq ft. The section across the stream of the burning mixture in the furnace is 10×15 ft, or 150 sq ft. Therefore, the coal in the half sq ft at the tip of the fuel nozzle must be distributed evenly over a section of 150 sq ft, an area 300 times as large as the area of the tip of the nozzle; and this distribution should be accomplished in a distance of 3 or 4 ft from the burner.

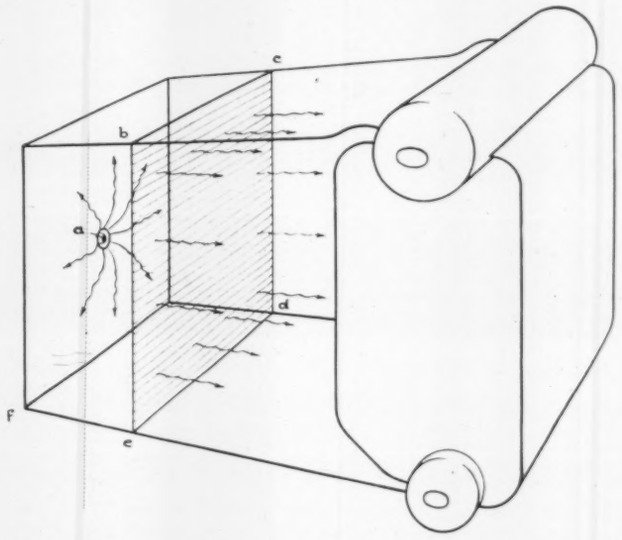

FIG. 3 DISTRIBUTION OF COAL IN FURNACE WITH A SINGLE BURNER
(Coal in tip of coal nozzle *a* must be distributed evenly over an area *b*, *c*, *d*, *e* about 300 times as large as area of tip of the nozzle within a short distance, *f*, *e*, from the burner. Even distribution in tip of nozzle results in even distribution of coal in furnace.)

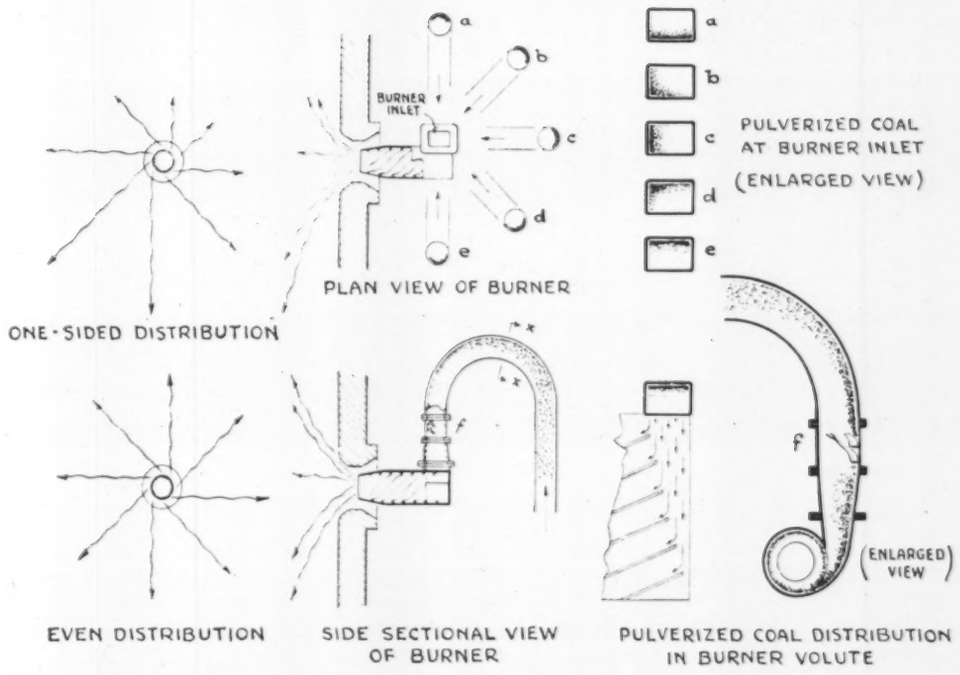

FIG. 4 DISTRIBUTION OF COAL IN FUEL PIPE AND IN FUEL NOZZLE

(Bend in fuel pipe causes concentration of coal at outer wall of curve, as shown at cross section *X-X* in fuel pipe, with curvature in five different vertical planes, *a*, *b*, *c*, *d*, and *e*. These concentrations of coal in fuel pipe cause corresponding concentration in rectangular fuel-nozzle inlet *a*, *b*, *c*, *d*, and *e* of enlarged view at right. Only bends in planes *a* and *e* will give a ribbon of coal of uniform concentration from which a number of smaller ribbons with equal concentration can be cut by helical strips inside fuel nozzle, shown in development of inner surface at lower right-hand corner. In fuel pipe with bends in plane *b*, *c*, and *d*, helical vanes in rotatable ring *f* must be adjusted to shift concentration to produce this ribbon with uniform concentration shown in *e*.)

It will be readily seen that the more bushy is the flame, the shorter the distance from the burner in which the fuel and air can be spread uniformly across the entire cross section of the furnace. The bushing of the flame is proportional to the rotative movement of the mixture of fuel and primary air and also the rotative movement of the secondary air. The smaller the pitch of rotation, the greater will be the bushing out of the flame. By the pitch of rotation is meant the horizontal distance the fuel or the air moves through the burner in making one revolution. The small pitch requires higher pressure both of the primary and secondary air. Usually, better combustion is obtained, that is, lower content of combustible in the flue dust, with a bushing flame and higher air pressure than with long flame. This better combustion results from greater turbulence and more even distribution of the fuel over the entire cross section of the stream of moving gases through the furnace.

To make bushing of the flame effective, it is necessary that the pulverized coal should be evenly distributed around the periphery of the tip of the coal nozzle. This even distribution of coal around the periphery of the nozzle tip is the most difficult problem to solve, because it is affected not only by burner design but by the shape of the fuel piping. The rotative movement of the coal mixture through the coal nozzle tends to concentrate the coal along the walls of the coal nozzle so that, when the coal mixture leaves the nozzle tip and enters the furnace, a large part of the coal is concentrated in a ring, the tip of the nozzle being the outside circumference of this ring. The different segments of this ring of concentrated coal are thrown nearly radially into the space of the furnace. Using the simile of the sunflower, each segment of this ring with the concentrated coal spreads out into a petal form. It is obvious that, if some sectors of this ring contain more coal than others, the part of the furnace space receiving these sectors will contain more coal than other parts of the furnace which received the sectors with smaller amounts of coal. If the distribution of secondary air is uniform around the periphery of the burner throat, there will not be sufficient air for combustion in the parts of the furnace which received the sectors with the larger quantities of coal, and there will be too much air in the parts of the furnace which received the sectors with the small quantity of coal.

The mixture of coal and air flowing through a fuel pipe is never uniform, and even if it is made uniform by some contrivance it will not remain uniform. The proportion of coal and air in every part of the cross section of the stream is constantly changing. When a fuel pipe has a curve, as all fuel pipes generally have, coal tends to concentrate on the outside of the curve. Usually, when the stream reaches the burner, a large part of the coal is concentrated in a small segment of the cross section. If nothing is done to break up this concentration, the coal, when leaving the burner nozzle, will be thrown to one side of the furnace. This defect is probably the most common found in servicing new installations and may occur in spite of all the care given to the burner design. The benefits of a good burner design may be nullified by an extra bend in the pipe made necessary to clear a duct or a bin or other structures.

Burner designers are endeavoring to get uniform concentration of coal around the periphery of the tip of the burner nozzle by different methods. One such method brings the coal into the burner in a wide and comparatively thin layer making a ribbon about 10 in. wide and about 2 in. thick. In the barrel of the burner nozzle are cast helical strips about $^1/_2$ in. wide and $^3/_4$ in. high, in such a manner that each successive strip extends farther across the entering ribbon of concentrated coal, so that this ribbon is cut into a number of smaller ribbons, each traveling in a helix between two adjacent strips to the tip of the nozzle. Thus if a uniform coal distribution is obtained in the ribbon entering the burner, there will be uniform distribution around the periphery of the tip of the nozzle and even distribution of fuel in the furnace.

The mills are usually located wherever there happens to be a good place for them. Often such location requires a fuel pipe with a number of bends in different planes, which makes it impossible to predict where the concentration of coal is likely to be at the point where the fuel enters the burner.

If the heavy coal concentration of the stream of mixture entering the burner moves toward the middle of the ribbon, it will distribute itself nearly evenly the full width of the ribbon. If, however, the heavy concentration happens to move toward either edge of the ribbon, the coal will not distribute evenly and the fire will be one-sided. In such cases the part of the stream with heavy coal concentration can be shifted toward the middle of the ribbon by means of helical vanes in a rotatable ring placed at the inlet to the burner shown in Fig. 4. In reality these vanes are equivalent to an additional bend in the fuel pipe which can be readily adjusted to neutralize the bad effect of the necessary bends. These adjustable vanes can be used to advantage also for vertical firing with the direct-firing system, where more bends in the fuel pipes are required than in a storage system.

With even distribution of fuel, there must be even distribution of air. The secondary air enters the furnace through the annular ring between the throat of the burner and the tip of the nozzle. It is given rotation by adjustable vanes. Even distribution of air can be obtained if the approach of air to the vane is the same all around the burner. The air comes to the burner through a duct either at one or both sides of the burner, top or bottom or both. The approach may be such that the path of the flow of air is more direct to some of the vanes than to the others. For example, if the air enters the burner from one side, the vanes nearest that side, being in the direct path of the flow, get more air than the vanes on the opposite side. As a result of this uneven approach of the air to the vanes, one side of the furnace may get more air than the other. Where there is unequal distribution of fuel and unequal distribution of air, one side of the furnace may get most of the coal and the other most of the air; this results in a very one-sided bad-looking fire.

In large furnaces with more than one burner, the burners should be located in the burner wall in such a way that the burners distribute the coal and air over an equal area of the cross section of the path of the burning mixture. Inasmuch as the streams from the burners intermingle to some extent, a small unevenness in the distribution in individual burners may be compensated by the other burners if a lean mixture from one burner intermingles with a rich mixture from another burner. If, however, a rich mixture intermingles with a rich mixture, no benefit is derived. It is certain that consistently better results can be obtained if the distribution within each individual burner is even.

TANGENTIAL FIRING

With tangential firing, streams of fuel and air are directed from the four corners of the furnace tangent to a small circle in the center of the furnace. Enough primary air is supplied to start ignition, but no attempts are made to mix the secondary air with the fuel at the burners. The ignited mixture is blown toward the center of the furnace, and the force of the streams from the four corners produces rotative movement. The rotative movement of the burning mixture in the burner zone is much greater than the rising movement, and the intermingling of the streams equalizes the distribution of coal and air across the furnace. It is comparatively easy in the tangential method of firing to get a uniform distribution of coal and air in the furnace. Even unusual bends in the fuel pipes have little effect on the even distribution of coal in the furnace. As a result of this good distribution, units fired tangentially require comparatively little servicing.

The important feature in tangential firing is that the fuel streams and the secondary-air streams in each corner move in the same directions. The secondary-air ports are wide compared to their length, and the bends preceding these air ports may influence the direction of the air streams. The designer must compensate the effects of the bends in the air ducts to obtain the desired direction of the air streams entering the furnace.

Even distribution of fuel and air in the furnace is the basic principle of good combustion. Turbulence or intensive mixing are means for obtaining even distribution of fuel and air in the furnace. Intensive mixing is a rapid relative motion between combustible and free oxygen. It moves combustible from one part of the furnace with little or no free oxygen to another space where free oxygen is available. It also moves the free oxygen from one space with no combustible to another space where there is combustible to be burned.

Buick

AIRPLANE-ENGINE CYLINDER HEADS BEING CHECKED FOR DIMENSIONAL ACCURACY

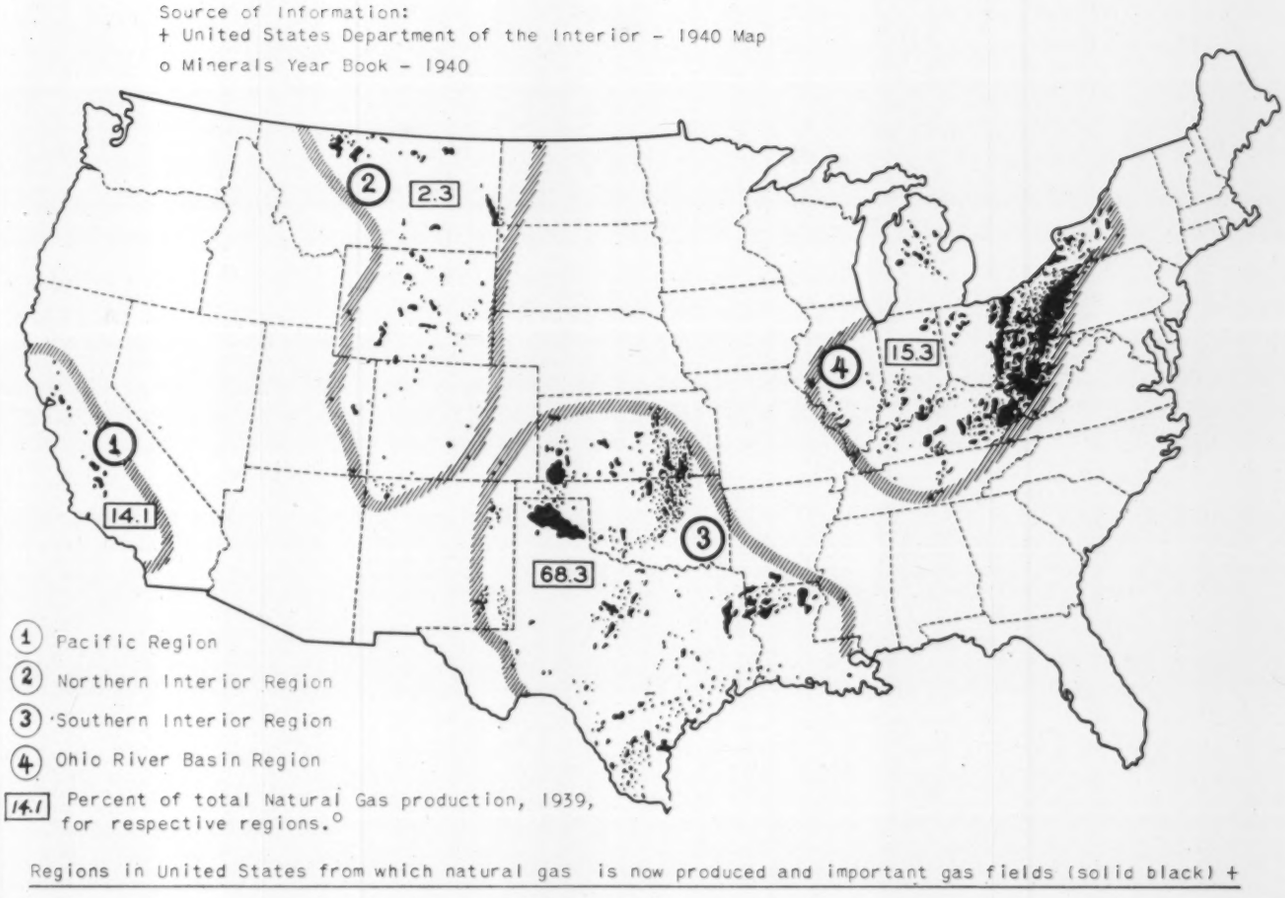
Source of Information:
+ United States Department of the Interior - 1940 Map
o Minerals Year Book - 1940
2
2.3
4
15.3
1
14.1
3
68.3
1 Pacific Region
2 Northern Interior Region
3 Southern Interior Region
4 Ohio River Basin Region
14.1 Percent of total Natural Gas production, 1939, for respective regions.°
Regions in United States from which natural gas is now produced and important gas fields (solid black) +

FIG. 1 NATURAL-GAS-PRODUCING AREAS OF THE UNITED STATES

NATURAL GAS *in the* U. S. A.

Its Production, Distribution, and Utilization

By W. B. POOR

UNITED GAS PIPE LINE COMPANY, SHREVEPORT, LA.

DURING 1941 natural gas was produced in commercial quantities in 26 states and delivered to consumers in 35 states. Marketed production for 1940 was in excess of 2654 billion cu ft, having a value at points of consumption in excess of $534,000,000.[1] Preliminary figures for 1941 indicate a marketed production approximating three trillion cu ft.

PRODUCTION

The production of natural gas is closely allied with the production of petroleum exemplified by the fact that, in 1939, 45 per cent[1] of the total gas production was from wells classified as oil producers.

The gas-producing areas may be geographically classified into four groups, i.e., the Pacific Region of California; the Northern Interior Region, comprising Montana, Wyoming, Utah, and Colorado; the Southern Interior Region of New Mexico, Kansas, Oklahoma, Arkansas, Texas, Louisiana, and Mississippi; and the Ohio River Basin area of New York, Pennsylvania, Ohio, Indiana, Michigan, Illinois, West Virginia, and Kentucky. These four areas (Fig. 1 and Table 1) furnish, respectively, 14.1 per cent, 2.3 per cent, 68.3 per cent, and 15.3 per cent of the natural gas produced in the United States.[1] Of these four producing areas only one, the Southern Interior Region, produced gas in excess of the market requirements within the area. From this area, Texas, Louisiana, and New Mexico exported, respectively, to other states and Mexico 182.9, 129.7, and 21.3 billion cu ft.

At the present time the quantity of proved natural-gas reserves has arisen primarily from the demand and, from areas other than the Ohio River Basin region, particularly from the

[1] U. S. Bureau of Mines.

Contributed by the Fuels Division and presented at the Spring Meeting, Houston, Texas, March 23-25, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

TABLE 1 MARKETED PRODUCTION OF NATURAL GAS IN THE UNITED STATES, BY STATES, 1937–1941[a]

State	Production, millions of cu ft				
	1937	1938	1939	1940	1941
Arkansas	9,690	11,301	10,107	14,379	15,800[b]
California	329,769	315,168	348,361	351,950	363,000[b]
Colorado	3,186	1,904	2,015	2,533	....
Illinois	1,040	1,169	2,746	8,359	....
Indiana	1,551	1,299	791	1,137	....
Kansas	83,890	75,203	80,556	90,003	100,800[b]
Kentucky	55,719	46,163	47,771	53,056	....
Louisiana	315,301	283,899	294,370	343,191	442,000[c]
Michigan	9,080	10,165	10,726	12,648	....
Mississippi	13,348	13,656	14,527	6,365	3,880[d]
Missouri	444	1,369	538	310	....
Montana	24,765	21,216	23,178	26,231	....
New Mexico	46,337	50,706	60,284	63,990	....
New York	21,325	39,402	29,222	12,187	....
Ohio	42,783	35,257	36,469	40,639	....
Oklahoma	296,260	263,164	250,875	257,626	....
Pennsylvania	115,928	76,547	93,882	90,725	....
South Dakota	10	10	10	9	....
Tennessee	17	6	8	9	....
Texas	854,561	882,473	979,427	1,063,538	1,160,000[e]
West Virginia	149,084	134,342	159,226	188,751	200,000 Plus
Wyoming	31,023	26,678	26,614	27,346	30,000 Approx
Others	2,509	4,465	5,053	5,240	724,820[b]

[a] Bureau of Mines data except for 1941; 1941 partly estimated, as explained in note *f*.

[b] Estimated. "Others" for 1941 include Oklahoma production.

[c] State government data based on first 9 months.

[d] State government data.

[e] State government data based on first 10 months.

f Note on estimate for 1941 by *Oil Weekly:*

Total United States production for 1941, estimated by multiplying production in 1940 by ratio of natural-gasoline production in 1941 to natural-gasoline production in 1940, the same method used by the American Gas Association in arriving at round figure of 3 trillion cu ft in published data. This method sometimes results in considerable error but is probably the best way to reach an estimate without actual statistics, which are available only in a few states and included in the table.

Those state figures shown for 1941 and footnoted *b* were reached by applying to state-production data for 1940 the ratio method applied to United States production as explained. Natural-gasoline-production figures for 1941 were available only for Arkansas, California, Kansas, and Texas.

Production for "others" in 1941 estimated as the difference between estimated total United States production and sum of estimated and actual reported data for the individual states shown.

TABLE 2 UNITED STATES CONSUMPTION OF NATURAL GAS, BY CLASSES, 1937–1941[a]

Class	Consumption, millions of cu ft				
	1937	1938	1939	1940	1941[b]
Domestic	371,884	367,772	391,153	443,646	440,000
Commercial	117,390	114,296	118,334	134,644	140,000
Field use	651,320	659,203	680,884	711,861	750,000
Carbon black	341,085	324,950	347,270	368,802	390,000
Oil refineries	113,005	109,741	97,685	128,007	140,000
Electric power	170,567	169,988	191,131	183,156	200,000
Other industry	650,274	559,298	659,180	684,543	850,000
Total	2,415,525	2,305,248	2,4,637	2,654,659	2,910,000

[a] Bureau of Mines data except for 1941, that year being estimated, as explained in footnote *b*.

[b] Note on estimates for 1941, by *Oil Weekly:*

Domestic and commercial consumption figures increased over those for 1940 by about the same percentages estimated by the American Gas Association for 1941. The A.G.A. data do not include those companies marketing both natural and artificial gas.

Data for field consumption for 1941: Per cent increase 1941 over 1940 assumed the same as per cent increase 1940 over 1939.

Data for carbon black: Same method of estimation as for field consumption.

Refinery consumption 1941, based on 1940 data, increased by ratio of refinery throughput in 1940.

Power-utility consumption increase in 1941 assumed the same as the present increase for 1941, estimated by the American Gas Association.

"Other industry" consumption for 1941, based on per cent increase for "other industry" made by American Gas Association, but slightly higher.

demand for oil. Since science has maintained adequate development in the art of geophysical exploration as related to petroleum deposits, and equipment manufacturers have adequately kept pace with the requirements for deeper drilling, a review of the annual drilling programs for the last decade, Fig. 2, furnishes the best evidence with regard to the future. The year 1942, however, will probably see a definite decline in increased proved areas because of the curtailment of drilling, as occasioned by the Amended Conservation Order M-68 and Preference Rating Order P-98.

DISTRIBUTION

A total of 190,270 miles[2] of pipe line formed the network of facilities, Fig. 3, through which 2654 billion cu ft of natural gas were distributed to consumers in 35 states during 1940. Of these facilities, 84,700 miles[2] were main transmission lines and 105,570 miles[2] distribution lines.

The year 1941 saw a sharp upturn in natural-gas pipe-line construction brought about to a large extent by the rapid increase in fuel demands of defense areas. During the year 1659 miles[3] of transit line were reported as completed, and there were under construction 216 miles[3] and proposed pipe lines amounted to 1870 miles.[3] The majority of the 1941 construction, 1442 miles, was in lines originating in the Texas and Louisiana producing area.

This enormous network of distribution facilities has been developed primarily during the last two decades. By the middle twenties there had come a real appreciation of the commercial possibilities of large-scale natural-gas distribution, thereby stimulating improvement in transmission facilities. The development of high-tensile steels by the tubular-goods industry and improvements in the art of welding both contributed greatly toward affording a transmission medium by which natural gas could be transported economically for long distances to manufacturing centers.

With this transmission development heavy industries in the North and East and in California were soon being provided with natural gas. The trend of transporting gas to locations of existing industries continued at a high rate until the depression of the early thirties. In recent years, however, there seems to have been in heavy industry a decided trend toward locating plants closer to the sources of basic materials and fuel. This has been particularly true of such industries as the pulp and paper, heavy chemicals, and metallurgical.

UTILIZATION

The rapid development of the utilization of natural gas is paralleled only by that of American industry in general. Much of our industrial development and expansion has taken place during the last quarter century. With this

[2] Authority, American Gas Association Annual Report, January, 1942.

[3] Authority, *Oil Weekly*, Jan. 26, 1942.

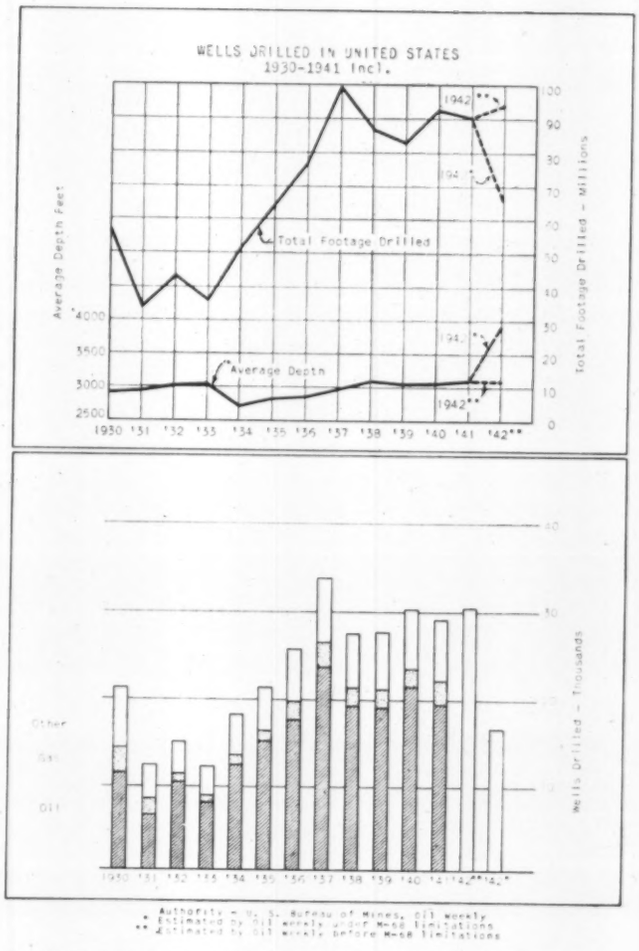

FIG. 2 WELLS DRILLED IN THE UNITED STATES, 1930–1941

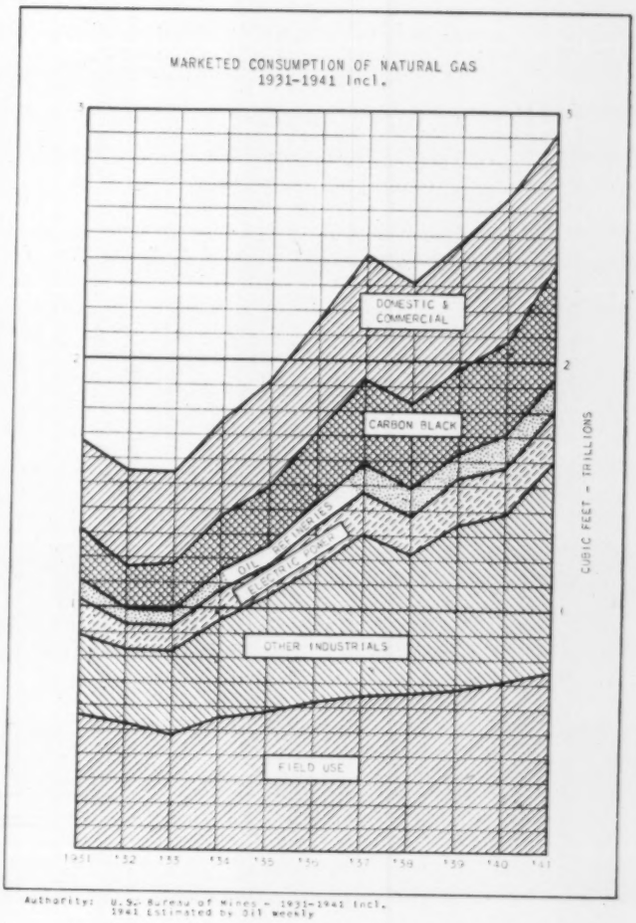

FIG. 4 MARKETED CONSUMPTION OF NATURAL GAS, 1930–1941

FIG. 3 NATURAL-GAS PIPE LINES IN THE UNITED STATES, 1941

expansion came new and unprecedented demands for better and greater sources of energy. In meeting these demands natural gas has become recognized as ideal particularly for industrial uses.

Today natural gas is widely used not only as a primary fuel but also as a processing agent and a source of raw material.

As a primary fuel it provides needed heat for steam-electric power generation, oil refineries, and fuel for prime movers of the internal-combustion type. It is recognized as an ideal fuel for space heating in the home, factory, store, office building, schoolhouse, and hospital.

As a processing agent natural gas provides means for the precision control of heat so necessary in the heat-treatment of metals, and in the manufacture of plastics, ceramics, glass, foods—in fact in almost all industrially processed products.

As a new source of raw material natural gas contributes essential ingredients in the manufacture of synthetic rubber and plastics, high-octane motor fuels, solvents for paints and varnishes, hydrogenated fats such as shortening and other cooking compounds, carbon black, explosives, and other items too numerous to mention.

The number of products and compounds that may be made from natural gas and its by-products is so great that present utilization, as a raw material and processing agent, is considered to be only a beginning.

The year 1941 witnessed the natural-gas industry increase its marketed consumption 10 per cent from 2654 billion cu ft in 1940 to approximately 2910 billion cu ft (Fig. 4 and Table 2). This increase was largely because of the accelerated demands of national defense and widening applications of gas. Industrial gas requirements other than for carbon black, electric-power generation, and oil refineries increased 24 per cent; oil refineries and electric power generation, 9 per cent each; carbon-black plants, 6 per cent; field use for drilling, gasoline plants, power, etc., 5 per cent; while domestic and commercial utilization remained practically stable, attributable to the mild winter and spring of 1941.

The future appears to be particularly promising for the utilization of natural gas. The tendency toward decentralization of industry should be extremely beneficial to those areas where an abundance of natural gas exists.

The domestic use of natural gas, where it is used for cooking and for the many heating jobs in thousands of homes throughout the country, is expected to maintain a steady normal increase.

The industrial consumption of natural gas, however, has great potentialities. New means of smelting iron ores from reserves never before commercially exploited are now in the pilot-plant stage at which natural gas is used in low-temperature reduction of the ore. In our present war production of aluminum and magnesium, natural gas is a highly desirable fuel.

In the manufacturing industries, some processes are materially accelerated through the use of natural gas. For example, the American Gas Association reports that in a modern tank gas is used in some 15 different heat-treating operations in hardening the armor plate, accomplishing a superior result with a heating cycle of about 100 hr, as compared with 400 to 600 hr during the last war.

It is logical to predict that natural gas will assume a position of even greater importance as the war program continues and during the period to follow. As industrial expansion continues it is certain that additional uses will be found for natural gas as a source of raw materials, and as a processing agent it is ot be used more extensively than ever before.

The Philosophy of Engineering Education

(*Continued from page 342*)

science of vocational guidance, training, adjustment, and engineering education by contributions to tests of mentality, skills, interests, and aptitudes. The diagnosis of personality is one of the baffling problems now being attacked from which one conclusion is clear, viz., that it is important and difficult.

Engineering education has long acknowledged its responsibility for the development of character and has now begun to assist students to correct personal habits, to control emotions, and to add social qualities which promote effective and enjoyable living. Engineering education encourages the excursion of psychologists into the realm of human relations in industry, in the scientific spirit. The co-operation of psychologists has already produced significant results where only recently the ground was barren. The alertness of industry and engineering to the values of studies in this area is a spur to what was only an academic approach. Arts and science are running on parallel tracks to the advantage of both.

The control of physical forces has gone far and is proceeding under the magic of the research laboratory into the realm of the invisibly small and the infinitely remote.

SOCIAL CONTROL

Planning for the advance of society in the pursuit of its objectives is at present marked by fundamental conflicts of opposing philosophies which may be disastrous. The opportunity which the sociologists have for the study of forces and trends is momentous. The other sciences await their conclusions.

Social evolution is taking place with such rapidity that it outstrips the pace of its interpreters. The sociologist is displaced by the politician. Research is needed. All forms of education, secondary, collegiate, and adult, are necessary to stem an emotional tide which may engulf democracy.

Engineering desires to embody the settled tenets of social-industrial relations when a dependable body of knowledge has been developed. Engineering education recognizes its place in, and its responsibilities for, participating in an economic plan which is as scientifically conceived as such a program may be in view of the emotional nature of the material with which it deals. Such a syllabus must be based on widespread education, a development of a degree of co-operation and idealism which is in conflict with selfishness, greed, prejudice, and hatred. The way is long and rough, but there is a great measure of human satisfaction at the end of the road.

If youth is confused by world events and by democratic policies in these United States, it is because schools, colleges, and churches have failed to sense the insidious effects of dry rot and have not strengthened the ship where it was weak.

If education is to play its part in the rebuilding of human ideals, it must map its course with more of emphasis on the foundation of character, with due appreciation of the dignity of the individual, but this individuality must be sensitive to the growing complexity of economic life and have faith in its ability to meet the issue.

The co-operative effort necessary to plan a better society compels the revision of our ideas of freedom of action, or independence. Readjustment involves revision upward of social and philosophic purposes to fit a war-weary world which will rebuild itself by the applications of science and the humanistic elements of education jointly conceived against a background of intelligent devotion to those inalienable rights which society may enjoy if it has faith in itself, foresight, and the determination to retain or resurrect them.

AIMS *and* OBJECTIVES *of*

The American Society of Mechanical Engineers

By HENRY H. SNELLING

WASHINGTON, D. C.

THE aims and objectives of The American Society of Mechanical Engineers were expressed almost 60 years ago in its charter as those best suited "to promote the Arts and Sciences connected with Engineering and Mechanical Construction for Scientific purposes, and to that end to meet and associate together to read and discuss professional papers, and to circulate, by means of publications among its members, the information thus obtained, and for the purpose of maintaining a library."

Our constitution amplifies these broad aims and specifies four further objects: i.e., To encourage original research; to foster engineering education; to advance the standard of engineering; and to broaden the usefulness of the engineering profession. A still further breakdown is set forth in the by-laws, which lists eight ways for advancing the theory and practice of engineering and the allied arts and sciences, seven ways for enhancing the status of the engineer, and five ways for increasing the usefulness of the organized engineering profession.

These specific objectives, as set forth in detail in the present by-laws, do not differ materially from those offered as ideals by our founder members some sixty years ago. The major differences, mainly in wording and in emphasis are due to basic changes in the structure of our political fabric. Our study in 1930 of the earnings of young mechanical engineers led to the formation of a comprehensive consideration of their development from school days until they were qualified as full members. Gradually this work has been taken over by the E.C.P.D. in which many of our members are actively engaged. We had a special committee, Committee on Aims and Organization, in 1919, and a Committee on Aims and Objectives in 1932, both of which after long effort brought forth reports which are reflected in the objectives of the present by-laws.

PRESENT CONDITIONS CALL FOR REVISION OF OBJECTIVES

The time is probably ripe for a further study of our aims and objectives to determine whether or not we are fully occupying our own field. Are we properly dividing our budget allowances between the various needs? Should we continue to encourage the formation of smaller societies each devoted to some one narrow field? Have we given the greatest possible impetus toward maximum participation of the individual member in this Society? These are questions that require study today.

You will note that no effort has ever been made to segregate the services of the Society to the individual member from the services to the profession at large. This was intentional for it was the thought that in many respects they were one and the same; that any service to the engineering profession would inure to the benefit of the membership at large, the public generally, and to the nation itself. Historically, we had special committees on standards for pipe threads and codes for boilers within months after the first standing committee was organized, and a quarter of a century before we had as many as two local sections.

Coming back to the official pronouncements before presenting a personal and therefore wholly unofficial viewpoint, the A.S.M.E. aims to advance the theory and practice of our chosen profession by giving encouragement to individuals, groups, committees, or institutions to proceed with original tests and research in the field of mechanical engineering. Our Standing Committee on Research was organized in 1909. It has nineteen subcommittees on technical research, varying from such general subjects as lubrication, fluid meters, thermal properties of steam, and strength of gear teeth, to highly specialized but important fields such as cottonseed processing and plasticity in the rolling of steel.

An idea of the importance of this work may be gained from a study of the personnel of the technical committees and of the standing committee itself. The latter includes members from Chicago, New York, Pittsburgh, Worcester, and Detroit. Two are directors of research in large nationally known corporations, one is a college professor, one is an important executive of a public utility, and the other, the present chairman, is a Babcock & Wilcox engineer. These men give graciously of their time and talents to make our organization known and respected throughout all the world.

INDIVIDUAL MEMBERS AIDED BY RESEARCH COMMITTEE

Primarily their work is regarded as for the general good but if we make a further search into their activities, we will find that the individual member is by no means forgotten. In collaboration with our headquarters staff, this research committee has presented most ably to employers and employees their relative rights in inventions made by research workers who are fully paid by a college or a research institution, which latter may or may not be serving as a research agency for an individual, a firm, or an association of corporations desiring solution of an engineering problem. Such a case, for example, is the development of reliable design data for an all-curved-surface external-pressure jacketed vessel.

In an address before the Society for the Promotion of Engineering Education a few years ago Mr. LePage, our assistant secretary, summed up the available data for the use of our Research Committee in formulating an A.S.M.E. policy relating to patents. In this paper,[1] both sides of the major questions were given with the author's own advice and this was followed by some ten separate discussions presenting varying viewpoints. One of these was by J. W. Walker, assistant general manager of The Detroit Edison Company (later appointed to the Committee on Research), who vigorously objected to the collection of royalties by a tax-supported institution. This position is interesting because of the great groups of patents now owned by government corporations, such as the Tennessee Valley Authority, which can and do protect their licensees by enforcing their patent rights. Dean Woolrich, now an A.S.M.E. vice-president, pointed out four items which he urged should be part of any research program, namely:

1 The research worker should be given inspiration, direc-

Presented before the Washington Section, Washington, D. C., October 9, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[1] "When Research Leads to Patents," by C. B. LePage, Proceedings, Society for the Promotion of Engineering Education, 1938, p. 520.

tion, and essential aid with assurance that his contribution will be appraised by a sympathetic board or committee, and he should have added reward for work of unusual value.

2 Those who provide the funds should be given assurance that their financial support is not for the personal gain of the research worker or the staff.

3 An invention should be fully covered by patent to protect the inventor, the institution, and the donor against an unprincipled application of the invention or discovery and excessive or uncontrolled production.

4 The research should be sufficiently financed, organized, and established to make possible the development of the invention beyond the laboratory state to actual pilot-plant installation, whereby the smaller manufacturer, who has but a limited research staff at best, can derive benefit from having the invention carried forward to the semicommercialized stage.

POLICY-GUIDING AUTHORITY FOR RESEARCH ACTIVITIES

Our Society for nearly 20 years has been acting as the custodian of funds that have been raised by research committees and are spent under their direction. The Society has become the fiscal agent and the policy-guiding authority for the administration of the particular research. This has required that we determine upon a policy carrying out the research objective in the fairest and most uniform manner possible, in view of the maze of conflicting and complicated elements usually involved, including law, business procedure, personal rights, self-interest, etc.

At the Council meetings in New Orleans and San Francisco in 1939, such a policy was adopted and model contracts were approved for the guidance of such research committees, which usually execute the contracts with the research agency and with the research workers.

We encourage the preparation of original papers on engineering topics through our Standing Committee on Publications, which selects addresses before the local sections, or other papers, for printing in the various publications, including MECHANICAL ENGINEERING, Transactions, and the *Journal of Applied Mechanics*. As you can readily guess, the selection of the matter to be published requires many hours of unselfish work on the part of the committee members who have shown much tact in carrying out this objective. We are proud of our editor, George A. Stetson. We have had many examples of his able presentation of subjects of the moment written in his direct, readable style.

PLANNING SOCIETY MEETINGS

We not only hold local and national meetings for the presentation and discussion of papers, but we wholeheartedly join in international engineering congresses and disseminate such knowledge and experience as may be of value to our members. Some months ago, an article[2] was published, discussing the meetings of the Society, showing that these are the result of long careful planning. This paper outlined the reasons which led the Committee on Meetings and Program to recommend to the Council that a policy of holding four meetings of the national Society each year be adopted. The committee had two objectives in mind: (1) To afford an opportunity for a majority of Society members to attend at least one major Society meeting each year without the necessity of traveling, what might be from some cities, an excessive distance; (2) to relieve the ever-growing pressure on the Annual-Meeting program. The article concludes with a paragraph which could be improved upon only with the greatest of difficulty; it will therefore be quoted exactly as written:

"The foregoing description of how national Society meetings are planned and conducted has attempted to touch on some of the important features that must be considered if successful meetings are to be expected. It is evident that this is a highly specialized business which involves innumerable details. The average member sees little of the machinery, knows less about the immense amount of work that is involved, and judges the meeting he attends largely from impressions he carries away with him. One object in describing a few of the principal details that must be given attention when the Society stages a national meeting is to attempt to convey an impression of what is involved and to awaken in members a realization of the debt they owe to the men who serve voluntarily on the many committees charged with responsibility for successful conventions. When it is considered that the bulk of the work connected with a Society meeting is conducted by men who must, at the same time, carry on the customary tasks and responsibilities of their own jobs, the truly democratic and co-operative quality of Society membership is strikingly brought into review. In terms of loyalty to their Society and their profession, the services of these men, voluntarily given for the benefit of their fellow members and the public, in work on Society meetings take on a high value. So long as this loyalty persists, the A.S.M.E. will continue to meet in an able manner the obligations implicit in its stated objectives. The means by which these obligations are met in planning and conducting Society meetings are representative of democratic traditions. The contributions made to the success of the meetings by the many members who take part in the planning and operating duties constitute real services to the public, as well as to The American Society of Mechanical Engineers."

STANDARDIZATION OF PRACTICES AND FORMULATION OF CODES

From almost its inception it has been one of the most important objectives of the A.S.M.E. to develop and promulgate standards, codes, formulas, and to recommend practices. It does my heart good to see our emblem on boiler fronts and other approved objects and to see the familiar four-leaf clover, on the books presenting such governing rules, received with such universal approval.

To my mind the prestige which the Society has accumulated through the years, as a result of this unselfish work on the part of our Standing Committees on Standardization, Safety and Power Test Codes, and the all-important Special Committee on Boiler Code, has been much more important to each individual member than would have been the same amount of money spent more selfishly on his own personal advancement.

It is the policy of the Boiler Code Committee to encourage suggestions for desired revision so that the code may at all times represent the best current practice. The committee acts with surprising promptness. Modifications which appear advisable are printed each month in MECHANICAL ENGINEERING under corresponding paragraph and section number for ready identification of the location of the proposed revision in the body of the code. The purpose of publication in this official organ of the Society is to give widest range for criticism or approval from those interested in the particular subject. After due notice, the amendment, with all comments, is presented for final reading in the committee and if approved the change is issued as one of the pink-colored addenda sheets, thus implying that the revision has been formally adopted as part of the code. In this way the code is always up to date.

HONORS AND AWARDS FOR MEMBERS

Our Standing Committee which carries out the objective of offering awards and other honors to encourage contributions to engineering, and in recognition of meritorious contributions, is

[2] "The A.S.M.E. Today," III—"Meetings of the Society Are the Result of Long and Careful Planning," MECHANICAL ENGINEERING, vol. 62, 1940, pp. 138–142.

called the Board of Honors and Awards. Among the awards are the Undergraduate Student Award, the Postgraduate Student Award, the Charles T. Main Award, the Junior Award, and the Pi Tau Sigma Award. The medals are the Spirit of St. Louis, the Melville, the Warner, the Holley, and the A.S.M.E. The awards are made annually with but few exceptions, whereas, two of the medals are awarded at irregular intervals. If the reader is interested in details of these honors and awards, descriptive material has been published previously.[3] These articles give not only the origin, scope, and purpose of the award or honor but include portraits of the various recipients in past years.

COMPLETE ENGINEERING LIBRARY MAINTAINED

It may be recalled that in our charter the maintenance of a library is mentioned. Unfortunately, this facility of the Society is little known to members outside the great metropolitan area. We have a Standing Committee on Library and, judging from the lack of complaint, they have done their work very well through a long period of years. The library is located in the headquarters building. It contains almost every book on engineering that has been published, about 140,000 volumes in all; and it subscribes regularly to foreign as well as to domestic engineering journals. Although it may not be generally known, any member may borrow a book from the library at a small mailing charge.

For the protection of its own members the technical and cultural standards for entrance into the Society are high but not unduly so. The cultural objective is gradually becoming more apparent. You may have noticed the great interest in the photographic exhibits at the national meetings and at the lectures on self-expression.

CO-OPERATION WITH EDUCATIONAL INSTITUTIONS

We co-operate with educational institutions in the maintenance of high standards of engineering education, as is best evidenced by our active support of the S.P.E.E. and by the presence among our standing committees of one entitled "Relations With Colleges." By this means, we keep in mind the changing conditions in the world in which we live. Precepts which the older members have cherished are thrown into the discard in favor of totally different concepts of the rights of government, and of groups and individuals. These changed conditions are reflected in the effort of the Society continuously to broaden the base of engineering education. Today, the field of study must include an understanding of the social sciences and the humanities. The proper place of the engineer in the present state of evolution of the social organization can be attained only if we teach the young engineer to understand and to appreciate the effects of these social changes.

He should be taught, in the engineering schools, to organize his thoughts in orderly fashion, not as formerly with heaps of ideas all askew. In this day and age, it is imperative that the engineer have a thorough grasp of the English language so that after he has marshaled his thoughts he can express his views confidently and convincingly.

Not only do we require a high standard of ethical practice by our own members but we have a Standing Committee on Professional Conduct. We invariably print with our Constitution and By-Laws the full approved Code of Ethics for engineers.

UNIFORM REQUIREMENTS PROMULGATED FOR PROFESSIONAL ENGINEERS

Under the lead of Past-President Herron, our Society has been active for many years in drafting suitable regulations governing the registration of professional engineers in the several states. This is in furtherance of our by-law requirement that we aid in the adoption of a high standard of attainment for the granting of the legal right to practice professional engineering.

Among engineering students, we have fostered the study of philosophy and history, tradition and achievement, duties and social functions of the engineering profession by articles which have appeared from time to time in MECHANICAL ENGINEERING, and by the publication of biographies of outstanding figures in the profession; among them being Hartness (machine-tool designer and Governor of Vermont); Brashear (astronomical devices); Thurston (our first President); Stevens (steam navigation); Gantt (management); and Sweet (straight-line steam engine).

ENCOURAGING YOUNG ENGINEERS

An appreciably large proportion of effort has been directed by the Council to the objective of encouraging the personal and professional development of the young engineer, and in seeking new opportunities for engineering service, in order to increase employment of engineers. This activity is familiar to most of us by the great encouragement given the junior groups. The Society has sought in every way possible to encourage the younger engineers to express themselves. This particular task is much more difficult in Washington than it is elsewhere. It is particularly so at the present time when the young engineer is hesitant to discuss anything connected with his government work, unless he is assured that the subject was well covered in an Encyclopaedia Britannica of at least ten years ago. As soon as the present emergency is over, our local sections will unquestionably seek to encourage the junior groups to hold meetings of their own, wherein the speakers themselves are members of those groups. The author sought to have this done a year ago, but, upon learning of the conditions governing the situation, was forced to agree fully with the able chairman of the local junior group that activities such as conducted by junior groups elsewhere had best be postponed.

CO-OPERATION WITH OTHER ORGANIZATIONS

The objective of increasing the usefulness of the organized mechanical-engineering profession by co-operating with other engineering and technical societies, and of encouraging engineers to participate in public affairs has been carried out quietly but effectively, largely by talks delivered at the various meetings by our officers and committee chairmen.

Naturally, complete co-operation in engineering matters is extended to government agencies. This has been done both directly and through the medium of the Engineering Council and the National Research Council, which is the engineer's liaison bureau with the War and Navy Departments. We regularly appoint representatives to other engineering organizations. Our by-laws give to the Council the right to appoint honorary vice-presidents to represent the A.S.M.E. at meetings of societies of kindred aim or at public functions. The same section of the by-laws authorizes the president to nominate members to represent the Society on professional or other committees organized by other societies or by other government departments or bureaus. I particularly remember this section of the by-laws, for my first official position with the A.S.M.E. was that of representative before the Department of Commerce, in 1919, at which time I had the pleasure of meeting and working with Herbert Hoover, then head of that Department. I learned more about wood in the few days on that committee than I had learned in all of the rest of my life before.

NATIONAL-DEFENSE PARTICIPATION

Nowhere in the official regulations will we find any reference

[3] "A.S.M.E. Honors and Awards," MECHANICAL ENGINEERING, vol. 60, 1938, pp. 758, 857, 963; vol. 61, 1939, pp. 168, 224, 302, 379, 536.

to national defense. Nevertheless, it is our prime objective today. Our Committee on National Defense now consists of fourteen members, all active. At the 1940 Semi-Annual Meeting in Milwaukee, our Council passed resolutions setting forth a nine-point program of service to the nation in the aid of national defense. As pointed out by the secretary at the business meeting, which approved the action of Council, there are three normal functions of the Society at such a time as this: namely, (1) To place at the disposal of those requiring the skill of the engineer such information concerning the qualifications and experience of the various A.S.M.E. members as will facilitate effective selection; (2) to provide a public forum for the discussion of problems specific to national defense; (3) to make available the skills of the various A.S.M.E. members in order best to give expert advice to the national agencies. As is doubtless well known, a number of our past-presidents are now $1-a-year men in Washington, and our Secretary's services have been made available to the government in his military rank as Colonel.

In line with these resolutions, our Society participated with the Civil Engineers in making a census of individual members and firms to be available for carrying out construction programs. We have held six National Defense Meetings, two in Pittsburgh, one each in Cincinnati, Cleveland, Philadelphia, and St. Louis, all well attended and productive of much good. We have been active in preventing senior engineering students from being drafted as infantrymen, when all the world knows today that battles are no longer won by heroism in the field but rather by excelling in the design of the implements of modern warfare. Battles are now won in advance at the drawing board and on the testing ground.

With the American Standards Association, we have brought forth Emergency Standards "for the duration." The first emergency standard sets up accuracy requirements for lathes, stated in terms of maximum permissible variations. Our efforts toward national defense approach that new but already trite adjective "all-out."

Aside from all printed pronouncements, our aim and objective is to give the individual member the greatest possible benefit in return for his service and his financial contribution. We are vitally interested in the welfare of our corporate members, for they are the Society. We encourage the juniors for they are the officers of tomorrow. We are as interested in the education of our student members as the nation is in that of its school children, and for the same reason. Most of all we desire that each and every member shall feel that we have his interest in mind at all times, that by our regulations we encourage each to participate in our activities, both local and national. As one means of accomplishing this, we bar second terms in one position on Council, except as to the Secretary and the Treasurer, in order to provide opportunities for participation by greater numbers.

LOCAL SECTIONS IMPORTANT TO WELFARE OF THE SOCIETY

The local sections are the backbone of the Society and in many instances are the sole tie between a member and the Society. Their welfare is fostered in every way. As with individuals, some local sections get along excellently with a per-member allowance that another local section of the same size finds inadequate. A constantly recurring question is the size of the formula or money quota. An unwritten rule of Council is that, in proposing an increase in a budget item, it must be shown specifically what other budget item should be decreased in like amount. It would be well if each of us should follow that rule, when we ask for a larger appropriation for a particular purpose.

For best results each member should make his wishes known. Our democratic style of organization facilitates this. At very least, a member may be sure that his views on any subject will receive sympathetic consideration if they are reasonable. There are three ways in which a good idea may be presented for adoption:

1 By direct or indirect contact with a council member, including the national committee chairmen.
2 By presenting it at a business meeting.
3 By bringing it to the national conference via the regional conference and the local section.

In addition, a member may secure the election of a Nominating Committee member who will work to secure a slate of persons sharing the desired view. This is not stuffing the Council but is the legitimate method of keeping our directors reflective of the sentiments of the majority.

There are questions to be decided which no one of us can answer. In the past we have encouraged those who are interested in such phases of our profession as welding, ventilation, standards, or automotive engineering, to form societies devoted solely to their individual fields. Naturally, for the same expense to members, these narrow-field societies can offer the specialist more in proportion to his expenditure. Is our policy wise, or should we make a greater effort to avoid these membership losses which have been considerable?

SHALL INDIVIDUAL SERVICE TO MEMBERS BE INCREASED?

Are we doing all we can do for the individual member? Dr. Durand believes that the present interests of the Society would be better served by increasing the service to the membership at the cost of some reduction in the service to the profession and to the world at large. His views are entitled to great weight, for he was our President in 1925, and is now Chairman of the Engineering and Industrial Research Division of the National Research Council in Washington. The author's viewpoint, however, is quite different. We wish to have an aggressive, enthusiastic, loyal membership with each man believing that the promotion of his professional welfare is our chief aim. It is, actually. We want and need the faith and confidence of our members. We want the members to be proud of their Society. The outstanding position of the Society, gained by service to the world at large, is a personal asset to everyone entitled to wear the A.S.M.E. emblem. In the author's estimation, we should not lower our national standing in order to advance the idea of greater individual service.

New Rubber Safety Equipment

IN the last War, workers in powder and shell factories often went barefoot to prevent blasts from body sparks caused by static electricity.

To remove this danger, a new conductive rubber was developed by United States Rubber Company which at the same time retains other rubber characteristics. When powder-plant workers' shoes have soles and heels of the new substance, the body electricity is dispersed through the feet into the flooring which may be made of the same material to carry off the charge.

Containers for the powder, table tops, and any other spot where electricity might collect, likewise make use of the material. Belting made of conductive rubber carries off the static electricity which collects from its motion. The material is particularly valuable for use in hose which may be charged with electricity, generated by the friction of particles passing through it.

In quantity production, cost of the new rubber will vary according to use. In general, it now runs about ten per cent above ordinary rubber.

The CAPACITY *of* AIR-CARRIER TERMINALS

Considerations Involved in Location and Arrangement

By A. F. BONNALIE

ASSISTANT TO EXECUTIVE VICE-PRESIDENT, OPERATIONS, UNITED AIR LINES, CHICAGO, ILL.

AIR-CARRIER traffic has reached such proportions as to raise the question of traffic saturation at major airports. During the Labor Day holiday of 1941, all-time peaks of airplane movements were experienced at all major terminals and the facilities were taxed to the utmost by the demands. LaGuardia Field, New York City, handled 1364 airplane movements between Thursday midnight, August 28, and Monday, September 1, midnight, 445 of these movements having occurred during the first 24 hours of the period (1).[1] Of this latter figure, 346 were scheduled air carriers. If the normal LaGuardia cyclic distribution prevailed (to be discussed later), 30 of these air-carrier airplane movements took place between 5 and 6 p.m. or one every 2 minutes. This is very close to the good-weather capacity of any field having a single system of runways.

The capacity of LaGuardia Field, using normal instrument down-through and departure procedures, is 11 airplane movements per hr, when close to minimum weather prevails. An approach control system (2) that was tried for some time increased this minimum weather capacity to 11 arrivals and 9 departures per hour. This development was handicapped by communication problems, and when these are ironed out, it is possible that this figure of 20 movements can be increased to about 25, or 83 per cent of the good-weather capacity of the field as against only 36 per cent when normal down-through and departure procedures are used. The so-called blind-landing system (3) when installed may still further increase this capacity, but it is more likely to make it more positive without amplifying it. Space does not permit a discussion of the details of these procedures (4). However, the foregoing figures show that the capacity of an airport is not necessarily determined by the size and arrangement of the runways, but involves the capacity of facilities that may be quite remote from the field itself. Accordingly, it has been necessary, in this study to give consideration to many phases of air-carrier terminal design, including the functional design of the air-way aids in the terminal country, the approach facilities, and arrangement of the field and its essential parts (5).

TWO SCHOOLS OF THOUGHT

Before going further, it is well to state that two definite schools of thought exist as to the future provisions for metropolitan carrier terminals. One school adheres to the principle that a multiplication of fields at major traffic centers is the only solution for the problem of the increased traffic that will develop in the future (6). Unquestionably, this is the simplest solution available, but it is subject to the same criticisms as are multiple-station facilities for railroads. Chicago's railroad stations are an example of the result of this type of thinking. The civic restrictions of multiple airports are not as serious as they are with railroad stations, but the problems of traffic interchange become intolerable because of the necessarily greater separation of airports. There are also the problems connected with the competitive situation. Again the railroad picture can be cited. The competitive advantages from passenger-terminal location (7) can be considerable, but so far, the air-transportation industry has preferred unified arrangements as witness the Air Line Terminal Building (8) in New York City.

The second school recognizes the desirability of the union type of terminal, feeling that the air carriers can best serve the public from one metropolitan airport. It is recognized that such a field may be somewhat remote from the city and its access difficult from a large part of the residential portions thereof. Proper civic planning, well-developed arterial highways, allowing express service, and similar devices, can alleviate the accessibility problem, particularly to the downtown section. On this score, it must be appreciated that about 35 per cent of all passengers at a representative airport such as Chicago are interchange or through passengers, and that 50 per cent of the remainder are away from home and almost entirely destined for or coming from the downtown hotel district. A substantial percentage of the remainder start or end their travels at the downtown business center, so it is probable that substantially less than 25 per cent of the passengers will be coming from or going to points not directly accessible to the airport, but they will be, in most cases, accessible to the downtown area. This distribution will fluctuate in accordance with the time of day and throughout the week, but it is believed it will average out about as stated.

CYCLIC TRENDS OF TRAVEL HABITS

The cyclic trends of travel habits have a real effect upon the capacity of an airport. The cycles are many, including hourly, daily, weekly, monthly, seasonal, and yearly cycles, jogged fairly frequently by holiday effects, and all superimposed on a curve of expanding air-carrier business. From the viewpoint of terminal capacity the daily and expanding business curves are most important, so the others will be neglected. There is some importance in the hourly cycle in that many departures are scheduled for the even hour or shortly thereafter. The half-hour is also popular. The traffic control exercised by the airport control tower must by necessity space these departures in accordance with the relative traffic, so the advertised departure time is always subject to amendment.

The seasonal or yearly cycle has a favorable effect in that the low business demands generally coincide with the period of the year when weather is the dominant problem in air-carrier operations.

R. G. Landis (6*a*) states that 12½ per cent of a day's volume

[1] Numbers in parentheses refer to Bibliography at end of paper.

Presented at the First Annual Aeronautic Conference of Illinois Institute of Technology, Chicago, Ill., Oct. 30–31, 1941.

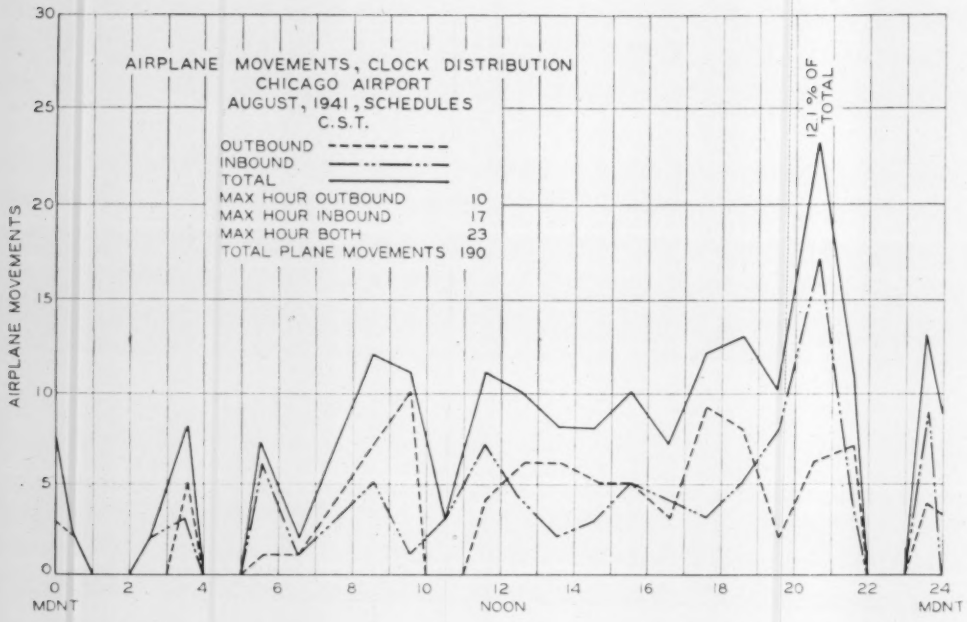

FIG. 1 CLOCK DISTRIBUTION OF AIRPLANE MOVEMENTS AT CHICAGO AIRPORT, AUGUST 1941

will be concentrated during one hour of the twenty four. This is true at Chicago as shown in Fig. 1, with 12.1 per cent of all schedules arriving or departing between 8 and 9 p.m. New York's peak is only two thirds as high as Chicago's, 8.6 per cent, and the total traffic is 28 per cent greater than at Chicago, as shown in Fig. 2.. Every field will have a different curve depending upon a number of factors. Some of them are as follows:

1 Experience proves that late afternoon departures are most popular with the traveler. This is particularly true in the eastern part of the country. Where short journeys are involved, fairly heavy demand exists from early morning until late in the evening, the lowest demand being in the middle of the morning from about 9 to 11 a.m.

2 For long overnight journeys, reasonably early morning arrivals are desired. The peak of arrivals will, however, usually occur in the evening because of the preponderance of relatively short trips at such important terminals as New York City, Washington, Boston, Los Angeles, and San Francisco.

3 Terminals intermediate on long runs have a cycle that is affected by the preferred departure and arrival times at points remote from them. This is one of the major items in Chicago's peak between 8 and 9 p.m. This point is further illustrated by Fig. 3, Cheyenne traffic distribution, a city about half way between Chicago and the Pacific Coast. About 60 per cent of the airplane movements at this field are transcontinental trips, and 70 per cent of the operations are between midnight and 10 a.m. with a peak of 26.6 per cent of all movements between 2 and 3 a.m. While only 34 plane movements are scheduled for each 24 hr, the general pattern would probably be found to prevail even with a considerable increase of operations.

There are other factors which affect the daily cycle, but the foregoing are most important. It is probable, therefore, that intermediate terminals on long routes will tend to have concentrated peaks of traffic of relatively short duration. As the im-

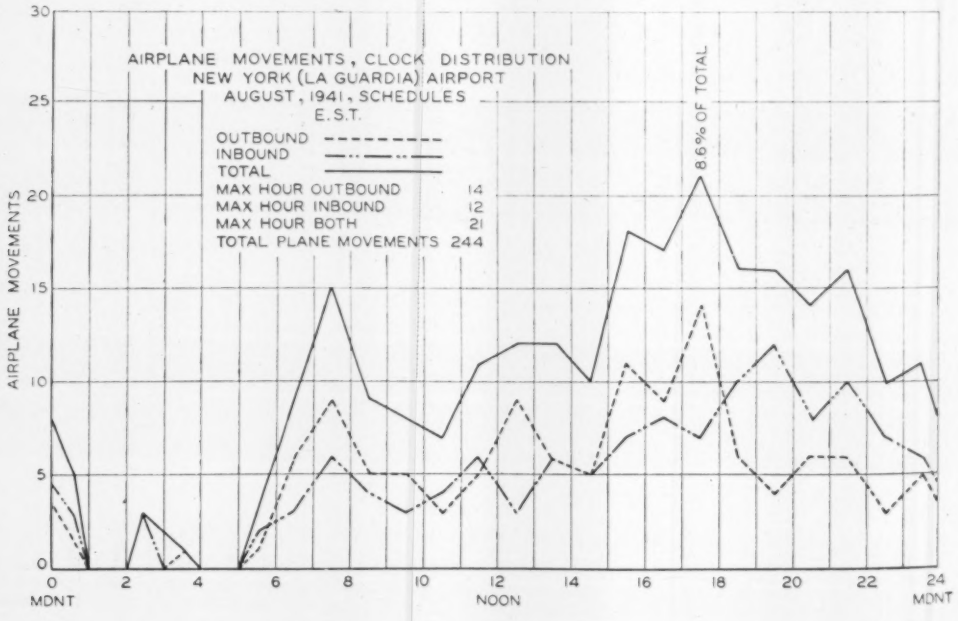

FIG. 2 CLOCK DISTRIBUTION OF AIRPLANE MOVEMENTS AT LAGUARDIA AIRPORT, NEW YORK, AUGUST, 1941

TABLE 1 DELAYS AT LAGUARDIA, TUESDAY, AUG. 19, 1941, BECAUSE OF WEATHER AND TRAFFIC

(ATC controlling)

Trip		Delay Hr-Min
UAL 36	Canceled at NK account LG traffic Scheduled arrival 9:32 p.m.....	
UAL 30	Scheduled arrival 11:14 p.m.....	1:08
UAL 22	Held at XA-scheduled arrival 10:18 p.m..	55
UAL 30B	Held at XA-scheduled arrival 11:14 p.m..	11
UAL 1	Scheduled departure 9:00 a.m.....	25
UAL 55	Scheduled departure 6:15 p.m.....	38
UAL 27	Scheduled departure 8:55 p.m.....	17
UAL 9	Scheduled departure 5:10 p.m.....	40
UAL 25	Scheduled departure 7:00 p.m.....	1:10
UAL 15	Scheduled departure 11:15 p.m.....	20
	Total delay (one canceled).....	5:44

LG—LaGuardia; XA—Allentown; NK—Newark; ATC—Airways Traffic Control, Civil Aeronautics Administration.

portance of such a terminal increases as a traffic center on its own merits, the general mass of operations will build up, somewhat alleviating the effect of the concentrated peaks of operations. Cheyenne can be considered an extreme case of the intermediate terminal, and Chicago such a terminal with considerable traffic originating and destined for it. LaGuardia is a terminal whose traffic is predominantly originating or terminating, and therefore it has a more massive traffic distribution, the peak being relatively lower.

The daily cycles shown in Figs. 1, 2, and 3 are idealized to the extent that only scheduled times are plotted. Weather sometimes enters the picture and changes the distribution radically.

Table 1 shows the result of close to minimum weather on one day at LaGuardia field. The results tabulated applied only to one carrier operating about 11 per cent of the total day's traffic, so it is reasonable to presume that this table shows only about one ninth of the delays experienced on that one day by all carriers.

FUTURE GROWTH OF AIR TRANSPORTATION

The probable future growth of air transportation is an important item in the study of airport capacity. There are several ways to approach an estimate for the future, but a forecast must give consideration to several rather important factors:

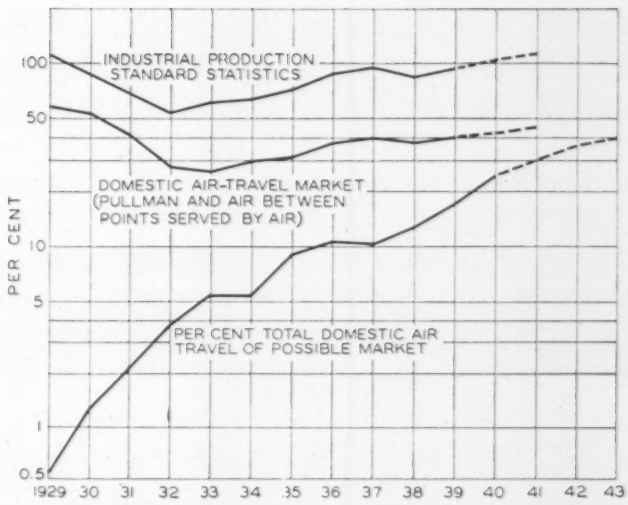
INDUSTRIAL PRODUCTION STANDARD STATISTICS
DOMESTIC AIR-TRAVEL MARKET (PULLMAN AND AIR BETWEEN POINTS SERVED BY AIR)
PER CENT TOTAL DOMESTIC AIR TRAVEL OF POSSIBLE MARKET
PER CENT
100
50
10
5
1
0.5
1929 30 31 32 33 34 35 36 37 38 39 40 41 42 43

FIG. 4 AIR TRAVEL PENETRATION INTO POSSIBLE TRAVEL MARKET

1 As long as air transportation remains a first-class-passenger, premium-mail, and high-cost-express carrier, its role is limited to some percentage of the total of its present competitive market. Considering passenger business as representative of the problem, the total competitive market is the sum of Pullman travel and air travel between those points served by air. This market now represents about 40 per cent of the long-distance first-class travel. This percentage will increase as air transportation serves more points; but, obviously, it will be a long time before any substantially large percentage of the towns where Pullman trains stop can be served by air. The small percentage that are served include all the larger cities, and accordingly a good percentage of the competitive business. On any division, based upon equal opportunity, it would be reasonable to expect the available travel market to split evenly between the airplane and the Pullman train. There are other factors that can effect a change in this but, being of little importance in this study, they will be ignored.

Fig. 4 shows the air-travel penetration into the market and the variation of the total market. It will be noted that, in 1940, the penetration was 24 per cent, and that the total market

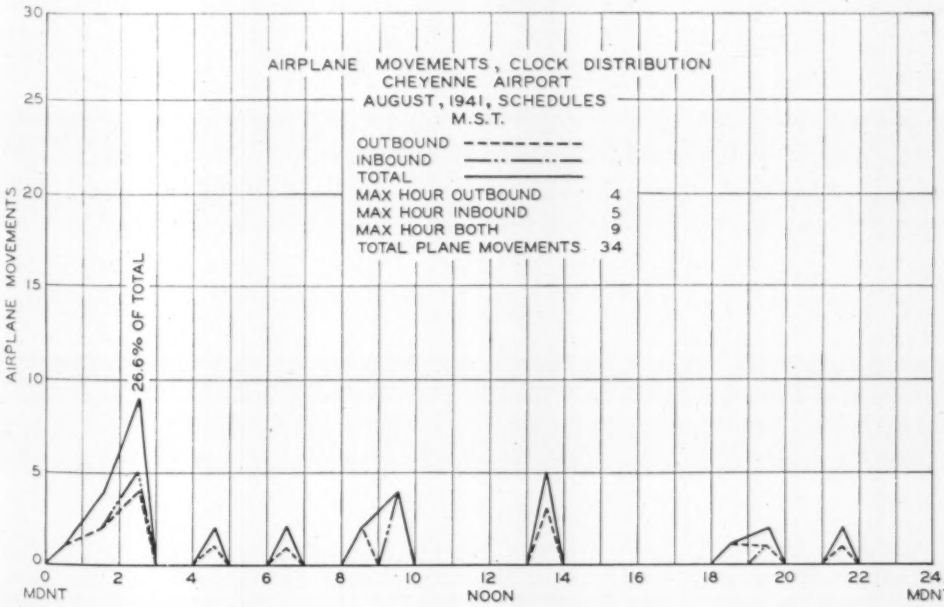

FIG. 3 CLOCK DISTRIBUTION OF AIRPLANE MOVEMENTS AT CHEYENNE AIRPORT, AUGUST, 1941

varies directly with the state of general business, measured in this case by the Standard Statistics index of production. The variation of total population is, of course, taken into account by this index; and it is quite possible, considering this approach alone, that the air-transportation business is now slightly less than one half its ultimate, even allowing for future increases in population and general business. The maximum penetration could be expected, had the war not intervened, by about 1947 or 1948.

2 The foregoing discounts the possible destruction of its competitors and the development of specialized traffic of its own by air transportation. Each new system of transportation does nurture the growth of some new type of travel, the greatest example being the results of the automobile. There is also some destructive effect by a new system of transportation upon its older competitor. Highway busses have proved to be most destructive to branch-line-railway passenger travel and the truck has done likewise to the short-haul freight business. Even long-distance travel and haul have been affected, for lower fares, "tourist" trains, toned-up services, "cannon-ball" freight, door-to-door service, and the like have shown the railroad reaction. That the competition of air travel has had a decided effect upon the railroads is evident for not only has it made definite inroads into the business, but the streamlined Pullman trains have been, to a large extent, inspired by the speed of the competitive service.

The extent of emergency traffic demands on the air carrier are an unknown quantity, but undoubtedly important. Much of this kind of travel can be considered as having been developed by the speed of air travel alone. There is other traffic carried by air that cannot use the older services because of their lack of speed. However, an estimate of the extent of these effects is not possible without the aid of extensive market surveys.

3 The public-service value of all long-distance first-class mail by air would be considerable. This is a very probable development at the close of the present emergency. Such an eventuality would increase the density of air traffic enormously and add immeasurably to the airport problems.

4 Economic studies of the effects of available but recent design advances in equipment indicate the possibility of entering the low-cost, long-distance, domestic-travel market. This, too, opens possibilities difficult to forecast but is a very probable development within a year or two of the close of hostilities, with the definite possibility of increasing passenger business manyfold.

5 Many people well informed on the subject feel that air cargo has possibilities of developing traffic to an enormous amount. The author is not so optimistic, but concedes that a decided increase in business can be developed. This will be true, particularly if the advances mentioned as item 4 are taken advantage of for cargo aircraft.

6 The probable increase in size of the unit airplane will have a very real effect on the traffic density in units of flying craft. The use of larger aircraft does not increase the traffic loading of a terminal, except in those parts directly concerned with the volume of passengers and tonnage of cargo involved.

Other more obscure factors are concerned, but it is felt that assuming a 25 per cent annual increase in business for the next few years is not at all out of order. It will be at least 4 years before larger equipment can be available in any quantity, so the estimates for the next few years are based on the assumption that the present size of equipment will remain substantially as it is, with further increases in demand to be accommodated by an increased size of vehicle.

It is reasonable, therefore, to expect a demand 4 years hence for about 735 plane movements for the maximum day at a city such as New York, and for Chicago, a year or two later. New York's peak traffic can then be expected to be something over 60 airplanes per hr, and at Chicago about 90 per hr, a year or two later. It is probable that by then the increased size of airplanes will flatten the growth curve of airplane movements.

During 1940, the average airplane (10) had $16\frac{1}{2}$ passenger seats, carried 9.6 revenue passengers and about 540 lb of baggage, mail, and express. The size of the average airplane has steadily increased, having provided 5.92 seats in 1932, 7.44 in 1934, and 10.8 in 1936. It has, accordingly, increased 53 per cent in 4 years. The size is still gradually changing in spite of no new designs becoming available, for the older smaller airplanes are being used less and less or are being completely replaced.

TERMINAL FACILITIES

Before taking up the subject of flight aids and facilities, it is desirable to give consideration to the terminal buildings and their size. In a study of capacity, we are most interested in peak loads.

The passengers through Chicago in January number only 36 per cent of those in August which is the peak month being 34 per cent above the year-around average. Furthermore, during the peak hour, the load factors are somewhat higher than the average daily load factor, particularly for cargo, where 200 per cent of average is not uncommon at the peak business hour.[2] Applying these ratios, it can be estimated that in about the year 1947 or 1948, the business during the peak hour at the end of August or early September at the Chicago Airport will be about as follows: Passengers, 1156; airplanes, 90;[3] cargo, $48\frac{1}{2}$ tons. About 36 per cent of this business will go through either on the airplane it came on or another within a short time. It is reasonable to suppose then, that of the passengers, 393 will come in and go right out, and the remainder will emplane or deplane, in about equal numbers. A total of 763 passengers will arrive at or leave the field by ground transportation, about 60 of them in private cars or taxicabs and the remainder in about 90 arriving or departing limousines. In addition, several post-office and express-company trucks will be necessary, so the road-vehicle-loading facilities will have to accommodate a total of about 100 units within 1 hr, or something more than 30 at one time.

The 90 airplanes involved during this hour will occupy loading positions for about 30 min each, plus 10 per cent to allow for choice and movement; so a total of 50 loading positions and gates will be necessary at this airport.

In order to service a through airplane, the following facilities must be available:

1 Gangway to passenger door.
2 Wheeled scaffold to front cargo pit.
3 Hand trucks to interchange cargo.
4 Ventilating equipment with heater for winter or cooler for summer.

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[2] They are decidedly higher later at night when cargo loads in excess of $1\frac{1}{2}$ tons per airplane are not uncommon.

[3] Estimates made by the Chicago Regional Planning Association (6c) are somewhat below this figure, but apparently allow for a considerable increase in the size of airplanes, which does not seem to be possible at an early date. The figures referred to are as given in the accompanying table of Schedule Plane Movements at Chicago.

SCHEDULED PLANE MOVEMENTS AT CHICAGO

(Arrivals and departures)

	Annual	Max, month	Max, day	Max, hour
1940 Actual.....	51200	5000	170	20
1945 Estimate.....	127000	12400	400	50
1950 Estimate.....	200000	20000	667	83

5 Fuel supply.
6 Mechanical service truck.
7 Commissary truck.
8 Mail truck.
9 Express truck.
10 Company cargo truck.
11 Incoming and outgoing baggage trucks.

A large part of this equipment is built up on light motor-truck chassis. At the new airports, ventilating, cooling, and heating services, as well as fuel service, are handled through piping from central facilities. At the smaller airports portable facilities are required. At the present time as many as seven motor trucks can be involved in the handling of one through airplane.

It is evident that the terminal building facilities are a problem of considerable magnitude that cannot be ignored in any study of capacity. It must also be remembered that probably the growth of air-transportation business will continue well beyond the date of 1946 and 1947. While the airplane will undoubtedly increase in size, thereby relieving the field problem, the number of passengers and amount of cargo will require facilities capable of considerable further expansion.

The movements of airplanes on and near the airport determine the requirements for the design of the field itself. Some of these needs are inferred in the foregoing, but it is necessary to list the major steps in the use of the airplane in order to understand the necessity for other facilities:

1 Moved from hangar or parking spot to loading ramp. (Applies only with originating trips or when change of equipment is necessary.)
2 Loaded with cargo and passengers. Through airplanes must be refueled and air-conditioned, sprayed for insects, odors, etc., and if necessary, washroom, toilets, and galley must be serviced. Cabin must be cleaned as necessary.
3 Taxied to take-off spot.
4 Take-off and depart.
5 En route.
6 Enter approach country.
7 Land.
8 Taxied to ramp.
9 Unloaded.
10 Taxied to hangar (applies on terminating trips only).

All but step 5, en route, are concerned with the terminal; two are concerned with the transitional stage between the air- and ground-borne condition; four are ground movements of the airplane, and one, plus part of another, are airplane movements in the air near the terminal.

Not all of the foregoing items will be discussed; most of them will be included by inference with those items most concerned with the airport capacity.

Reference (*2b*) describes the layout of the terminal country of the present Chicago airport. The average down-through procedure at this point occupies 11 min (11), and the interval between approaches is about 13 min, making the capacity of the system, in close to minimum weather, about 5 airplanes per hr. This is a typical layout of a present-day, heavy-traffic, terminal country. The facilities have been established by the trial-and-error system, and were installed one by one as the specific demands arose. The use of these facilities is thoroughly explained (*2b*) and will not be discussed here.

THEORETICAL DEVELOPMENT OF AN AIR TERMINAL

On the other hand, a somewhat theoretical and possibly academic development of an air terminal of high capacity will be undertaken. In so doing, the airport problem of Chicago will be kept in mind, but the author wishes to make it clear that he is not advocating the adoption of this plan. There are too many factors involved that cannot be considered here. The purpose is to study airport capacity alone and not city planning.

In the location of a terminal airport, two major, somewhat opposite requirements must be considered. To develop traffic, the airport must be close to the metropolitan center and, at the same time, the flight requirements demand extensive areas over which the airplanes can maneuver with safety and with the minimum nuisance effect to people on the ground. It is desirable that the terminal country be sparsely settled and that the actual approach zones to the airport be as free as possible from obstruction, particularly along the prolongations of the runways themselves. Grieme[4] has said that 69 per cent of all aircraft accidents occur on or within 5 miles of the airport. This

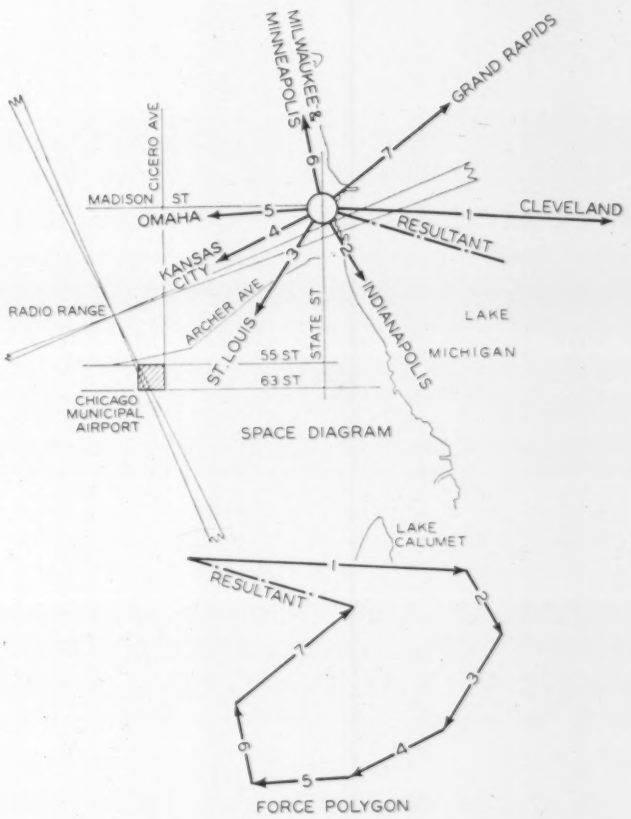


FIG. 5 RESULTANT OF ALL AIRPLANE MOVEMENTS FOR CHICAGO

figure probably includes all kinds of flying, not only air-carrier; but a number of serious air-carrier accidents can be directly laid to serious approach hazards, to inadequate airports, or improperly located ones.

The impossibility of locating the airport at the traffic center of a city necessitates its displacement to a more remote point. The relative accessibility of the possible sites is dependent upon many features of city growth and design that are redundant here, but the minimum interference to air travel will develop if the displacement is in the direction of the resultant of all air travel. Plotting the resultant of all airplane movements for Chicago gives the result shown in Fig. 5. This would seem to support the idea of a lake-front airport, but the necessity for it to be several miles off shore, and the amount of fill that would

[4] Fred H. Grieme, chief of Airport Section, C.A.A., at National Fire Protection Association meeting, Toronto, Canada, 1941.

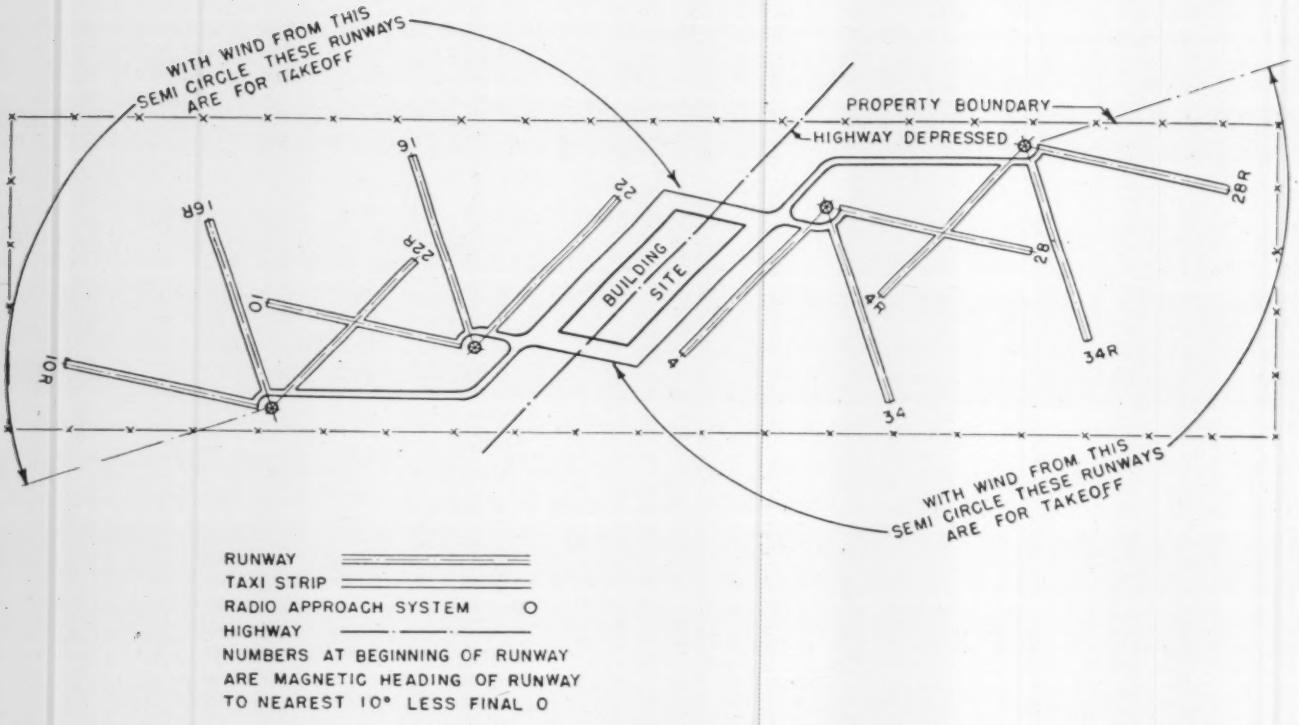


FIG. 6 LAYOUT OF HIGH-CAPACITY AIR TERMINAL

be necessary to make several square miles of dry land, together with the difficulty of providing the radio facilities, all present problems of considerable magnitude. The layout of the terminal country will be one of the major problems in developing the full capacity of any terminal. Generally speaking, most of the necessary radio facilities are either perfected and in use, or have at least reached a sufficiently advanced experimental stage to allow the probability of what follows to be quite definite.

RADIO-RANGE REQUIREMENTS

The present radio-range system, because of limited frequencies and static interference, cannot be considered adequate for the demands the future will make upon it. Ultra-high-frequency radio ranges (or possibly what are called microwaves) are accordingly necessary. These ranges will provide flight paths under the control of the terminal. A selection of ranges can be set up to bring the airplane in along any one of several entrance paths. A setup of this type has been in use on an experimental basis (2*a*). Position along the entrance paths in this proposed setup is to be fixed for the benefit of the pilot and controller by marker beacons which are modulated to operate colored lights on the instrument board and coded to give an aural recognition signal as well. The position will likewise be reported from the marker-beacon site by means of radio from the airplane to the receiver on the ground, piped into the control station. Excellent and complete communication among all concerned is an essential. The foregoing will, in fact, be a block signal system that will space airplanes exactly as desired by the controller and bring them along step by step into the terminal country.

Final approach to the airport is to be on a localizer and glide-path device similar to the one discussed by McIntosh (3). Mounting such a device at the intersection of the center lines of several runways allows it to be used for any one of them. The runway layout is shown in Fig. 6 of which more will be said later.

With something like the system described, it should be possible to bring airplanes along a given entrance and approach path at intervals of not to exceed 4 and possibly 3 minutes; some think 2 minutes. Two entrance and approach paths could then bring in 30 to 45 airplanes an hour. Two other paths for departure would allow the departure of a similar number of airplanes.

Earlier in this paper it was pointed out that a radio approach and control system similar to that just described has, at La-Guardia, allowed a present-day type of airport to handle 20 airplane movements per hr under instrument-flying conditions. This airport, like many others, is somewhat restricted on some of the approaches to its runways, but the provision for a complete duplication of runways to allow use of the FB (Floyd Bennett) range as an alternate approach would double the capacity to 40 airplane movements per hr. Additional take-off runways would again double the capacity. This indicates that the capacity of the hypothetical setup is not in the least fantastic, but is definitely within reach. In other words, a properly developed airway-radio-aids system within the terminal country will have a capacity in excess of even the largest present-day airports, not only during good weather, but when minimum conditions prevail as well.

The possibility of designing an airport of sufficient capacity now becomes the problem. A little earlier, some of the proportioning was mentioned with the discussion of the future demands on passenger, cargo, and airplane loading facilities. A parking space for 50 airplanes of the present sizes, wing tip to wing tip, will approximate a mile in length. This gives some idea of the sizes into which the whole project will grow. LaGuardia Field, whose good-weather capacity is 30 airplane movements, covers 558 acres. This is adequate for the runways and buildings, but inadequate in approach zones.

The Chicago Field is just short of 1 sq mile, say about 600 acres. It has duplicate runways allowing eight directions for simultaneous take-offs and landings but its buildings are small and the maneuvering areas and approach zones are heavily built up. To provide reasonable approach zones alone to the

Chicago Field would require the addition of at least 525 acres to the present property and the relocation of four important streets.

The problem of increasing airport capacity is not a simple one, but there are several approaches to a solution.

HOW TERMINAL CAPACITY MAY BE INCREASED

One obvious way to increase the capacity of a terminal is to spread the operations more evenly over the day. This effect is apparent in the LaGuardia traffic distribution. During periods of great demand, customers' preferences become subordinate to availability. It is accordingly to be expected that during the present period of rapidly increasing demand, and limitation on air-line equipment, a greater spread of operations will develop. In fact, something of this effect is included in the curves discussed, for the summer of 1941 had a substantial cutoff in volume of possible traffic, owing to the restricted air-carrier capacity, resulting from limitations in available equipment and flying personnel. This is shown by the load factors that prevailed over most of the country. Load factors in excess of 80 per cent have been common where experience shows that when load factors cross 70 per cent, the "unable to accommodate" replies to requests for transportation increase very rapidly.

PARALLEL RUNWAYS

Another obvious way to increase the capacity of an airport is to install parallel runways that can be used simultaneously. This has been done in Chicago (9). The advantages obtain mostly during good weather; for the bottleneck, when instrument-flying conditions prevail, is elsewhere. The Los Angeles Municipal Airport has three parallel runways into the prevailing wind, and Cleveland has a large all-way surface for multiple operations. This latter fails in its major purpose, however, for the airport control tower is unable to specify lanes of approach or ground movement and accordingly is able to allow only one movement at a time.

None of the installations mentioned can be considered entirely satisfactory, for approaches of more than one airplane at a time are an impossibility when restricted vision prevails, because of insufficient spacing of the approach lanes. Chicago and Los Angeles have one advantage in that one of the runways can be used for take-offs and another for landings. This brings up another method of increasing capacity, the complete separation of the various types of operation.

This separation of functions is one of the tools of production management and an obvious method of increasing output. At the present time, airport runways are used both for take-off and landing and frequently for taxiing.

The layout shown in Fig. 6 separates all functions. No runways are used for taxiing, for all are single-ended and are used toward the junction for landing and away from the junction on take-off. Duplicate runways are available for take-off and for landing as well, regardless of wind direction. The plan would allow triple runways if desired.

As the directions of each group of runways intersect at one point, a radio glide path and localizer can be set up capable of orientation in accordance with the wind. The parallel runways are spaced far enough apart to allow simultaneous use even under instrument conditions.

The taxi ways are so arranged that one-way traffic is in order. Hangar facilities and terminal buildings have sufficient frontage to allow for the traffic estimates presented earlier in this report.

The ground areas involved in this plan are enormous—7 or 8 sq miles in fact—but the capacity seems sufficient for anything now in sight and is capable of further expansion. If the stable undercarriage (tricycle) now being used extensively on high-performance military airplanes proves satisfactory, it may be possible to use runways in only two directions. This will allow the same capacity within a much smaller area, with the added advantage that one pair of runways for each function would be full length for use in light and prevailing winds. Those at right angles would be shorter, to be used only when the cross-wind component on the long runways exceeded a specified safe amount.

In conclusion, it would seem that there need be no particular fear that the capacity of the airport will cease to expand. Something like 1000 transport airplanes a day at one airport would seem ample, particularly when it is realized that all the elements necessary for achieving this figure are known. Furthermore, it is probable that airplanes of greater capacity will be available in a few years. All the instruments and devices have been developed and used in service; nothing of an untried nature is necessary of development. In fact, scientific progress is certain to improve the situation and probably make this study an underestimate within a few years.

BIBLIOGRAPHY

1 William Darby, Chief of Control Tower, LaGuardia, in the *New York Times*, Wednesday, Sept. 3, 1941.

2 (*a*) "Range Control at LaGuardia Field," by David S. Little, *Aero Digest*, vol. 38, Feb., 1941, pp. 46, 48, and 50. A discussion of the need for speeding up approach procedures during close to minimum weather and a description of the experimental range control being tested.

(*b*) "Reducing Stacking Delays," by C. H. McIntosh, *Aviation*, vol. 40, July, 1941, pp. 40–41, 156, 158, and 176. An excellent description of progress being made in the development of radio procedures and airway facilities near the terminals of Chicago and New York.

3 "C.A.A. Demonstrates Blind Landings," by Don Fink, *Aviation*, vol. 38, Oct., 1939, pp. 30, 31, and 76. A description of the radio facilities installed at the C.A.A. experimental center at Indianapolis for the testing of positive radio approach and landing procedures under instrument conditions. Ten similar installations are in process of installation at air-carrier terminals for service tests.

4 "Instrument and Radio Flying," by Karl Day, Air Associates, Inc. (published by author). The basic principles of instrument and radio flying procedures.

5 "Airport Design Information," Airport Division, Civil Aeronautics Administration, U. S. Department of Commerce. A pamphlet that is reissued from time to time discussing some locational, design, and construction factors for airports in general. Not specifically limited to air-carrier terminals or their locational and operational problems.

6 (*a*) R. G. Landis' speech at Louisville, Ky., 1940, and article in *Air Law Review*, Jan., 1941.

(*b*) "Airport Requirements in the New York Metropolitan Area," by R. S. Damon, presented before the Society of Terminal Engineers, New York, N. Y., May 9, 1940.

(*c*) "Airport Program 1941," Chicago Regional Planning Association. These references 6 (*a*), 6 (*b*), and 6 (*c*) present the multiple-terminal arguments fairly thoroughly.

7 "The Economic Theory of Railway Location," by A. M. Wellington, John Wiley & Sons, New York, N. Y., 1900. This classical work on railways discusses the competitive advantages of passenger-station location in chapter 3, "The Nature and Causes Connected With Location Which Modify the Volume of Railway Revenue."

8 "Air Lines Terminal in New York City," *American Aviation*, Jan. 1, 1941. Description and pictures of a Union downtown air-carrier passenger station located at 42nd Street and Park Avenue, New York. The limousines for all air carriers, foreign and domestic, that serve New York City leave from this building.

9 "Chicago Municipal Airport Improved With a System of Dual Runways," *Aero Digest*, vol. 38, Jan., 1941, p. 44. Discusses the runway layout at the enlarged Chicago Municipal Airport.

10 *Civil Aeronautics Journal*, Aug. 15, 1941, periodical of the Civil Aeronautics Administration, Statistics for 1940.

11 "Instrument Approach Time Summary—January, 1939, through December, 1940." Airways Traffic Control Section of Civil Aeronautics Administration. Data published semiannually for all major fields within A.T.C. control areas.

LOGISTICS—*The* PROBLEM *of* DELIVERING *the* GOODS

By JAMES L. WALSH

NEW YORK, N. Y.

THE science of war is divided very broadly into three branches: Strategy, the planning of war, which is carried out by moving colored pins on maps; tactics, the actual maneuvering of men and matériel on the battlefield (actually waging war, in other words); and logistics, the third branch, providing the means whereby tactical methods can be employed to achieve successfully the strategical plan. In other words, strategy is the plan, tactics the method, and logistics the means. Logistics covers a lot of ground. It is not a mysterious science that has to do only with the movement of troops and convoys; it concerns you and me.

When war was a duel between professional armies logistics did not amount to much. One man could probably keep one soldier at the front fairly well supplied with whatever he needed in the way of weapons, ammunition, food, clothing, and medical and surgical supplies. This phase of war was a thing apart from the national life. But the World War was found to be no longer a duel of professional armies; it was really a war between nations and groups of nations. The industrial revolution had been applied, in effect, to warfare. The development of the machine gun, the magazine rifle, and to some extent the tank, which was then in its infancy, had brought about a greater importance of munition power as compared to man power. Each man had a greater value and a greater striking power wrapped up in machines. Hence, logistics at that time became very important. As late as Oct. 3, 1918, during the Meuse-Argonne offensive, General Pershing cabled the War Department, "Unless supplies are furnished when and as needed, our armies will cease to function." That was only a month and eight days before the Armistice, so you can see how close the war came to turning out differently than it did.

Today, with total war and global war, we come to another phase where logistics, the means of doing things with men and materials, actually dictates strategy. We hear frequent questions: "Why don't we do this or that?" I will tell you why. It is because we haven't the means of doing it. Even if we have the means in the United States, we haven't yet the means to transport material to the scene of action.

HANDICAP OF DISTANCE

I am going to make a few points which I wish you would remember in the days to come. First of all, remember that in order to break even with the Japs we must outbuild them in ships eight to one. We have an average supply line of 12,000 miles and they an average supply line oversea of 1500. When you wonder why things are not done and done in a hurry, why we do not send over some pursuit planes that can travel 400 miles an hour, remember that those pursuit planes must be shipped more than 12,000 miles at the rate of ten miles an hour. It takes time to get them there where they are needed. That is a matter of cold fact. I tell you this because I want you to get the next point, which is that you can help to send planes over more promptly than they are going now. You can, in effect, "build" ships in your own backyard. For example, the Forest Products Laboratory, Madison, Wis., which is a long way from the seacoast, redesigned such a simple thing as a crate for automobile and motor-truck engines and cut down the bulk of that crate by 16 per cent. Such a reduction in size of crates means that five ships can do the work of six. Is there any quicker way to build a ship than not to need it? I ask you young men who are going to pay for all this, "Do you know any cheaper way than not to have to pay for it at all?" And this is not an isolated instance. It means simply that if we pay attention to things connected with the war effort we can be very helpful. After all, we Americans are not in this war incidentally or academically; we are in it actually. We are targets. Some of us are preferred targets, according to the locality in which we live. Let us remember that anything we do to shorten the war and bring it to a victorious conclusion is working for our own personal interest. We are working to save lives—perhaps our own lives.

WASTE WILL NOT WIN THE WAR

Some of you probably put a spoonful of sugar in your coffee tonight. Possibly you stirred it, maybe you didn't. If you did not stir it to get the full use of that spoonful of sugar, you were helping Hitler. It takes all the sugar that can be gathered from a fifth of an acre, distilled into alcohol, to make the powder necessary for one charge of a 16-inch gun. It is little simple things like that that we can do. We can cut down the time factor by using more efficiently things that are right in front of us. By saving the things that are needed and that take up supply transportation coming in and more supply transportation going out, we can increase the efficiency of that supply line.

Here is another point we can keep in mind. In the last year about 40,000 automobile accidents resulted in fatalities. Just by way of comparison, let me say that if you will take the number of automobile accidents that turned out fatally in any recent nineteen-month period you will find that it almost exactly equals the total number of deaths in the nineteen-month period of the first World War. So you can see what a terrific load we are carrying. We are killing as many people with the automobile bumper regularly as the enemy, with all his gas and tanks and bombs and everything else, killed during the first World War. We cannot afford it any longer. Formerly, if a man wanted to get killed in his automobile, that was up to him, but in a logistic sense, from now on we cannot afford the strain on the telephone system to get an ambulance, we cannot afford the doctor's time, we cannot even afford the rubber on the tires of the ambulance taking a useless needless trip to the hospital. These preventable accidents roll into tremendous figures. You and I can stop them. In one year, during 1941, there were enough man-hours lost in pre-

An address delivered at the Spring Meeting, Houston, Texas, March 3–25, 1942, of The American Society of Mechanical Engineers.

ventable work accidents to build 35 battleships, 15,000 heavy bombers, or 195,000 light tanks. That is what we have been throwing away in industrial accidents. Now, let's not get too cocky and say, "Oh, I drive safely." How about the home where 102,000 people were killed, while 40,000 were being killed on the automobile highways? 102,000 killed because Johnny left his roller skates in the front path and somebody skidded and broke his head; or some housewife got up on a chair instead of a stepladder and fell down; or one of us got into a bath tub and skidded on a cake of soap. All of that is something we cannot afford any longer. When we do things like that we are helping Hitler. When we avoid doing things like that we are helping to lick Hitler. It is up to us to choose.

Take the case of preventable illness, which is even worse. A man who is hurt—suppose he is a munition worker or an army man—not only knocks himself out of production, but he knocks out of production the person who is looking after him. When a man is ill he not only takes the doctor's time, the nurse's time, but he also is a menace to other people and puts them out of work. I shall not give you the figures to indicate how much time due to preventable illness we have thrown away in this last year—time we could have used to help win the war. With this careless, happy-go-lucky attitude of thinking, "Oh, well, it will be the other fellow, it won't be me," we go on recklessly risking accident or sudden death. We are facing this situation: Some of these things are no longer a matter of choice; we are coming into the clinch. We must make up our minds to do without luxuries in the way of accidents and illnesses and waste. Congress appropriated billions of dollars but they could not appropriate a single second of time. You and I and every other American can, in effect, "appropriate" time by saving the time we are now wasting.

TIME THE IMPORTANT FACTOR

When Pershing was cabling for supplies did he mean supplies at the end of the production line or did he mean supplies 3000 miles away on the firing line in France? We have not finished the job by any means just because we have produced so many thousand tanks and so many thousand guns and so many thousand planes. We must place them where they are useful, and that is the big job. That is why we cannot afford to do foolish things. We have been wasting time, stultifying the military effort. It comes back to a question of logistics. Supply lines are life lines now. As a matter of fact, today, far from being a problem of supplying an army in the field, logistics comes down to the cold-blooded proposition, "Can we maintain the existence of the civilian populations of the United Nations and maintain their armies in the field until we get the preponderance sufficient to overwhelm our enemies?" Everything we do that subtracts from that effort, whether it is carelessness or wastage, we are taking out of our own hides. Everything we do in the way of conservation and conversion is helpful in winning the war. Everything I have mentioned, bulk and weight and the like, comes down to a single least common denominator—time. And do not forget that when you are thinking in terms of time and saving time you are saving human lives. That is the currency with which you are working. And when I say saving human lives I mean that you are perhaps saving your own lives. That is just how important it is to you.

The $56,000,000,000 that was appropriated for this next fiscal year would build 160 Panama Canals in one year, that is, about three a week. It took ten years to build the Panama Canal. That is the size of this job. That is why the armed forces must be backed up by civilians, and we do not have to be led by the hand and shown a blueprint to know how to do it. We have enough native American ingenuity to think things out by ourselves. Take such a simple matter as shipping citrus fruit. The waste going on today by shipping, say, 360 boxes of oranges in a refrigerator car that will hold 630 means that we can increase the number of refrigerator cars available in this vicinity by 75 per cent just by loading them to capacity. Let's not talk about the 40-hour week alone. We do many things, wasting vital transportation, for example, that help Hitler just as much as limitation of production.

A BALANCED PROGRAM NEEDED

What we must come to when all is said and done is a balanced program. You and I can help there, too. It is all right to speak of 10,000 tanks—we can make them. But 10,000 tanks are not nearly as valuable as if we were to make only 8000 and were to devote the man-hours on the last 2000 to making spare parts. Then we would have 8000 tanks fit for service at all times instead of 10,000, some of them out of order. We are getting reports now about what is called "cannibalism." we send out a tank completely assembled, but it may be broken down and everything from a cotter pin to a carburetor taken from it to repair another tank. That is the most expensive way in the world to ship spare parts—by using transportation for assembled units which are later broken down, wasting the time to assemble them, the space to ship them, and the time to disassemble them just to provide spare parts.

I think you and I understand the situation well enough. Where would we be without automobile service stations? How could we travel any distance in this country if service stations were not available? Let us not make it a political issue to make 10,000 tanks if 8000 would be better with the necessary spare parts and the necessary ships to get them to the scene of action. We must stop waste at the source, before the steel is committed, before it gets into a tank that cannot be shipped. We must get it back at the steelmill and put it into a ship to carry equipment overseas, or into spare parts to keep the equipment in working order. Then we can go ahead on a balanced program.

When we do that we will begin to see light ahead. We have the production facilities, we have the ingenuity, and this Society—I know I speak for all of the members—has shown by its past conduct that it has the nerve and the courage and the patriotism to follow through until the war is won.

WAR-WASTE POSTER MAKES EFFECTIVE DISPLAY

(The original of this poster is 22 by 30 inches and is printed in red, white, and blue. The Jas. P. Marsh Corporation, Chicago, has printed copies, full size and in color, with the name space blank, which may be obtained in reasonable quantities for the asking.)

Don't waste it!
EVERYONE agrees that production will win the war. The greater the production—the more efficient the production—the quicker the victory will come.
But . . . production rests on material. And material is so scarce that our government has found it necessary to ration it. . . . . .
The work we are doing here is sufficiently essential to earn us the privilege of obtaining some particularly scarce and vital materials. . . . . .
That means jobs for us and the privilege of doing our part. . . . . .
Let's not abuse this privilege! Let's show our appreciation of it by doing everything in our power to prevent waste and spoilage of metals and materials of all kinds.
Save materials here, save them at home, save as you have never saved before. Every ounce of metal and material you save is a contribution to victory for
. . . . all of US . . . .
JAS. P. MARSH CORPORATION

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Aviation Physiology

SCIENCE

SOME of the problems of aviation medicine and their importance were brought out in a recent lecture[1] by Dr. J. F. Fulton of the Laboratory of Physiology, Yale University School of Medicine, who says that on the successful solution of several such problems will depend in large measure the outcome of the present war.

The modern aeronautical engineer, says Dr. Fulton, has placed primary emphasis upon design, upon the attainment of speed and quick maneuverability; in some modern combat planes virtually everything has been sacrificed to gain these two objectives—everything sacrificed, including the pilot. It is no secret, for example, that until very recently some of the new bombers designed to fly at 35,000 ft were so cold inside at that altitude as to make it quite impossible for a crew to function effectively for more than a few minutes.

The second development in modern combat flying has arisen from recognition of the need for protecting the pilot, and at long last aviation engineers are getting together with flight surgeons—and even with physiologists—recognizing that the physical limitations of the pilot are quite as important as the physical characteristics of the machine, and that both must be considered in designing and operating combat aircraft. I propose to deal with three phases of the problem, all essentially physiological, affecting pilot performance at high altitudes, (1) temperature, (2) aeroembolism and (3) effects of high acceleration.

TEMPERATURE

Under standard atmospheric conditions the temperature at 38,000 ft is —55 F; above that stratospheric level the temperature falls but little. The pilot, or the gunner in the open turret, exposed to such a temperature for 8 hr with the wind velocity of 200 mph is worthless as a gunner; occasionally indeed he has turned to be a cake of ice.

The designing engineers have given us planes that will fly to 35,000 and even 40,000 ft, but at first they largely forgot the pilot and the crew, believing that inconveniences from extremes of temperature could be taken care of by clothes from the Quartermasters' Corps. In single-motored fighter planes, there is little trouble from cold, even in the high-altitude ranges, since the pilot sits behind the engine and the cockpit receives direct warmth from it; but in all larger twin-motored or four-motored planes, especially the long-range bombers, the bomb bay is generally open to the outside air, and the heating arrangements, especially in the American-made planes, have been virtually useless. Enormous quantities of heat are available from the exhaust of the long-range bombers, and with little alteration in basic design the exhaust could be made to heat any strategic point in the plane, including the gunner's position.

Numerous proposals have been made to combat low temperatures, e.g., electrically heated suits, boots, and gloves, and there have been many designs of other types of clothing. Most acute, however, is the need for an oxygen mask and an oxygen line of supply that does not freeze up during prolonged exposure to low temperatures. The Army and Navy have recently released for manufacturers their criteria for oxygen-supply systems in which they insist that the oxygen mask and accessory supply valves must not freeze up in one hour with a temperature of —40 C in the face of a wind velocity of 10 mph at an altitude of 37,500 ft. Every mask commercially available at the present time freezes up solid after about 10 min of such punishment. Those of you who have recently seen the popular film "Dive Bomber" will have had vividly portrayed the consequences of a frozen system of oxygen supply.

And there are also many vicious circles in connection with cold and high altitude. If very heavy clothing is worn, the crew must do more work in moving about and hence requires more oxygen. If the oxygen supply clogs or freezes at 35,000 ft, especially that of a crew member moving heavy bombs, he falls unconscious within 15 sec or less and the duties of other crew members are generally of such a nature as to prevent their giving prompt assistance. I cannot tell you in detail how the problem of cold is being met here or in England, but one can say this, that the flight surgeon is still forced to employ many awkward expedients—all of them I hope temporary—until the heating engineers have solved their phase of the problem, which includes heating as well as ventilation, and also watching for carbon monoxide and other toxic gases.

AEROEMBOLISM

Some of the faster interceptor planes may gain altitude at the surprising rate of a mile a minute; this brings them, if that rate of ascent is maintained, from sea level to 35,000 ft in roughly 7 min. Actually, the rate of ascent is inevitably slower in the rarified air, but it is stated in the newspapers that some of our new fighters have attained altitudes of 36,000 and 37,000 ft within 10 min of the time they took off. The pressure of air at 34,000 ft is a quarter of that at sea level—190 mm Hg instead of 760 mm. An aviator arising to 34,000 ft thus subjects himself to the same relative decompression as that experienced by a diver ascending from 100 ft of water—which is equivalent to 4 atmospheres—to the surface level. If a diver ascends too rapidly, nitrogen bubbles tend to form in the tissues and blood stream, and in the same way aviators who subject themselves to rapid decompression are likely to experience the symptoms of bubble formation in their tissues. To divers and to caisson workers, the painful syndrome has long been known as "bends" because the excruciating character of the pains causes those affected to "double up."

Owing to the developments of the last year, most of which are about to be described in an important paper by Lieutenant

[1] "Physiology and High-Altitude Flying With Particular Reference to Air Embolism and the Effects of Acceleration," Sigma Xi Lecture delivered before the Yale Chapter in Sage Hall, Yale University, Wednesday, October 15, 1941, and The Duke University Medical Defense Symposium, October 16, 1941. Published in *Science*, February 27, 1942, p. 207.

Commander A. R. Behnke in the next number of the Military Surgeon, "bends" would seem no longer to be a serious problem in military aviation. The new developments may be briefly outlined as follows:

Denitrogenation (a) With Oxygen. It has long been suspected that "bends" arise primarily from nitrogen bubbles rather than from oxygen, carbon dioxide, or the rarer gases, since nitrogen comprises 80 per cent of normal air and is rather slow to pass through cell membranes. Once a nitrogen bubble appears, therefore, it is not rapidly absorbed. By breathing pure oxygen for a prolonged period, all the nitrogen of the body, or virtually all of it, can be disposed of. Dr. Behnke has found that when the body is completely denitrogenated, previously susceptible subjects fail, after exposure of several hours to altitudes of 40,000 ft, to develop "bends." Unfortunately the curve of nitrogen elimination indicates that pure oxygen must be breathed for at least 5 hr before 95 per cent of the body's nitrogen is eliminated. Obviously, therefore, preoxygenation is not a feasible way of preventing "bends," especially for fighter pilots who could not be expected to stay in an atmosphere of pure oxygen for 5 hr prior to each ascent. The same is true of bomber crews. However, an hour of breathing pure oxygen, as, for example, if the pilot puts on his oxygen mask immediately he enters his plane, will diminish "bends" susceptibility, but will not prevent its ultimate appearance if the exposure to high altitude continues for a long period. In a susceptible subject studied by Commander Behnke severe "bends" developed between 25,000 and 28,000 ft without preoxygenation. With 45 min preoxygenation "bends" did not develop until 30,000 ft; with 90 min preoxygenation the ceiling was raised to 34,000 ft; with 3 hr, to 37,000 ft; and after 5 hr preoxygenation the susceptible subject withstood 40,000 ft for 2 full hours without experiencing symptoms.

(b) Helium. Oxygen for prolonged administration is hazardous because of its toxicity. Nitrogen can be removed as effectively from the body with a helium-oxygen mixture as with pure oxygen. Since helium is only one third as soluble in fat as is nitrogen, the quantity of gas available for bubble formation, especially in the bone marrow, which comprises as much as 90 per cent fat, is greatly reduced. If a human being were saturated with helium, instead of nitrogen, it would require only 90 min of oxygen inhalation to eliminate dissolved helium in contrast to the 5-hr period for nitrogen elimination. Commander Behnke believes it would be practicable to have bomber pilots in a ready room filled with an atmosphere of oxygen and helium prior to flight. So far, this proposal has not had service trial.

Preselection for High-Altitude Service. The susceptibility to "bends" varies enormously in different individuals, and little is known as yet of the basis for the differing susceptibilities. Pilots in the age group of 18 to 24 can often withstand prolonged exposures to altitudes as high as 40,000 ft, and it has now become possible on the basis of decompression-chamber tests to single out for the high-altitude squadrons those pilots who can stand, say, 35,000 ft for 4 hr without developing untoward symptoms. Hence, if pilots are selected through preliminary decompression-chamber tests as fit for high-altitude operations, "bends" ceases to be a serious military problem.

EFFECTS OF ACCELERATION

An aircraft flying along the curve of any circle, whether in pulling out of a dive, a tight turn, or a diving spiral, will have acting upon it from the center of the circle a centrifugal acceleration which varies directly as the square of the linear velocity and inversely as the radius of the circle. The actual weight attained by a body during acceleration is the product of the mass and the acceleration expressed in terms of the normal attraction of gravity, i.e., 1 *g*. At a centrifugal acceleration of 7 times the force of gravity (7 *g*), a pilot weighing 180 lb normally would have a weight, so long as the 7 *g* is sustained, of 1260 lb. Every tissue in the body takes part in this increase in weight and as the current R.A.F. Manual puts it "at 6.9 *g* the blood becomes as heavy as molten iron." During such acceleration the weight of the hydrostatic column of blood is too great for the heart to cope with on the arterial side and venous blood fails to be returned to the heart from regions of the body below the cardiac level. Hence there tends to be a pooling of blood in the abdomen and lower extremities and failure of the cerebral circulation. The effect of diminished circulation to the retina of the eye manifests itself in graying, and finally in ultimate failure of vision—giving the phenomenon of "blackout." When vision goes, consciousness is likely to fail shortly thereafter.

There is a time factor in acceleration as important physiologically as the absolute magnitude of the centrifugal force itself. The average young adult can withstand sitting in the upright position 5 *g* for 4.5 sec. He might also stand 7 *g* for 2 sec, but no normal adult can withstand 7 *g* for 7 sec without complete loss of consiousness.

The capacity to withstand acceleration varies in different individuals, and in the same individual at different times. Test pilots have found that an alcoholic spree of an evening considerably diminishes their tolerance for positive acceleration the next day. Relative anoxia, such as may occur in high altitudes when the oxygen supply is inadequate, likewise diminishes resistance to acceleration, and it is likely that the level of the blood sugar is similarly important. In recent German literature various expedients have been recommended to assist the pilot to withstand positive acceleration. These may be enumerated briefly.

Full Stomach. In the recently published diary, "I was a Nazi Flier," there is a diverting chapter on aviation medical research in Germany in which it is stated that all resistance on the part of pilots to being experimented upon was overcome when it became known that the "doctors" had recommended that the pilots of Stuka dive bombers should have a large beefsteak before going off on a mission. From other sources it is clear that the German flight surgeons insist that an empty stomach diminishes tolerance to high acceleration. When the stomach is full the visceral blood vessels are also distended so that more blood cannot readily enter them—so runs the German explanation. Blood chemistry, no doubt, also plays a part in determining resistance to *g*.

Carbon Dioxide. Use of 5 or 6 per cent carbon dioxide, which through increasing the cerebral circulation is said by the Germans to increase resistance to acceleration by from 1 to 2 *g* (Ruff and Strughold). This is doubted by other authorities.

Vasoconstrictor Drugs. Any pharmaceutical agent which increases the "tone" of the capillary wall improves one's *g* ceiling. Pituitrin, adrenalin, and adrenal cortical hormones have all been mentioned in this connection, but precise data concerning these are not available.

Pneumatic Belts. Mechanical constriction of the abdomen as well as the lower extremities has also been proposed in both the German and English literature to minimize the rush of blood from the head to the visceral bed and the lower extremeties. Of these mechanical devices, pneumatic belts and pneumatic trousers have been most under discussion. The Germans state that a pneumatic belt may increase *g* tolerance by from 1 to 1.5, but no one of the present belligerent countries has permitted publication of detailed reports concerning the actual effectiveness of this equipment.

Water Suits. The Germans have also reported on a "water suit" designed for the prevention of blacking out, and while

they claim it notably improves resistance to positive acceleration they state that it is unsatisfactory for other reasons. To quote Grow and Armstrong (1941, pp. 276–277):

> The water suit is a closely fitted water-proof garment which is worn next to the skin. What little space is left in the suit after it is put on is filled with water or other suitable fluid. This causes the flier to "float" in the suit, and during accelerations the water presses on the body equally in all directions. As a consequence the normal effects of acceleration are replaced by a uniform compression of the body which, it is estimated, could be tolerated without difficulty up to 15 *g*'s or more.

Posture. In a recent paper by Ruff (1940) in Medizinische Klinik, the problem of posture in relation to acceleration was discussed. The Germans, it appears, favor a crouching posture with flexion of the legs against the abodmen as one particularly suited for protection of the pilot against acceleration. This would bring the hydrostatic column of blood in the leg veins nearer to the heart level. If the pilot lies supine or prone at the end of a dive-bombing maneuver, he is also less subject to negative acceleration, but in these postures he is unable to see out or to maneuver his plane without special redesigning of the cockpit and the cockpit controls.

It should be noted that all factors tending to improve the body's resistance to positive acceleration are those which tend to keep blood in the head. From this it may be concluded that the phenomenon of blacking-out and loss of consciousness which may occur within 5 sec of the beginning of the acceleration is probably due solely to acute anoxia, and cannot be attributed to any direct effect of acceleration per se upon the cortical neurons.

Many other phases of aviation medicine might be discussed, but since there are certain topics that cannot be gone into fully at the present time, I have omitted mention of night vision, instrument lighting, the oxygen mask, the adrenals, and Drs. Nims and Clarke's studies of pH in anoxia, until some later time when restrictions are less imperative than at present.

Pumps for Oil-Well Cementing

A.S.M.E. SPRING MEETING

UNDER the auspices of the Petroleum Division at the A.S.M.E. Spring Meeting at Houston, Texas, on March 23–25, 1942, Wm. D. Owsley, supervisor, mechanical research and development department of the Halliburton Oil Well Company, Duncan, Oklahoma, presented a paper entitled, "Pumping Equipment for Oil-Well Cementing," an abstract of which follows.

The designing of pump units for oil-well cementing presents one of the most unsual and interesting problems found in the design of oil-field equipment. The primary function of the pump unit is to perform the specialized work of cementing casing in all kinds of wells. Equally important are the secondary functions of remedial cementing, controlling wild wells, loosening stuck drill pipe, and doing other work for which the drilling-rig pumps are not suited. The equipment necessary for this variety of services is usually furnished by a company which is organized for that specific purpose.

In order to offer these services economically and quickly, the service company must be able to cover large areas with a minimum number of units and be able to reach all locations under every condition of weather and roads.

A modern cementing unit is composed of two or more pumps, a cement mixer, a water tank, and the necessary manifolds, connections, and auxiliary devices, all mounted on or carried in one large truck. Most of the trucks have four-wheel drive with heavy high-reduction transmission powered by large gasoline or Diesel engines. Usually the truck is equipped with a winch which can be used in traversing bad roads. This truck unit must be designed to meet the many state regulations governing the size and weight of motor vehicles. These legal requirements frequently add many complications to the design of such equipment.

The pumps are the heart of this extraordinary assembly and their design presents an interesting study of an unconventional adaptation of fluid-handling machinery. In addition to being suitable for truck mounting and as light as possible, oil-well cementing pumps are designed:

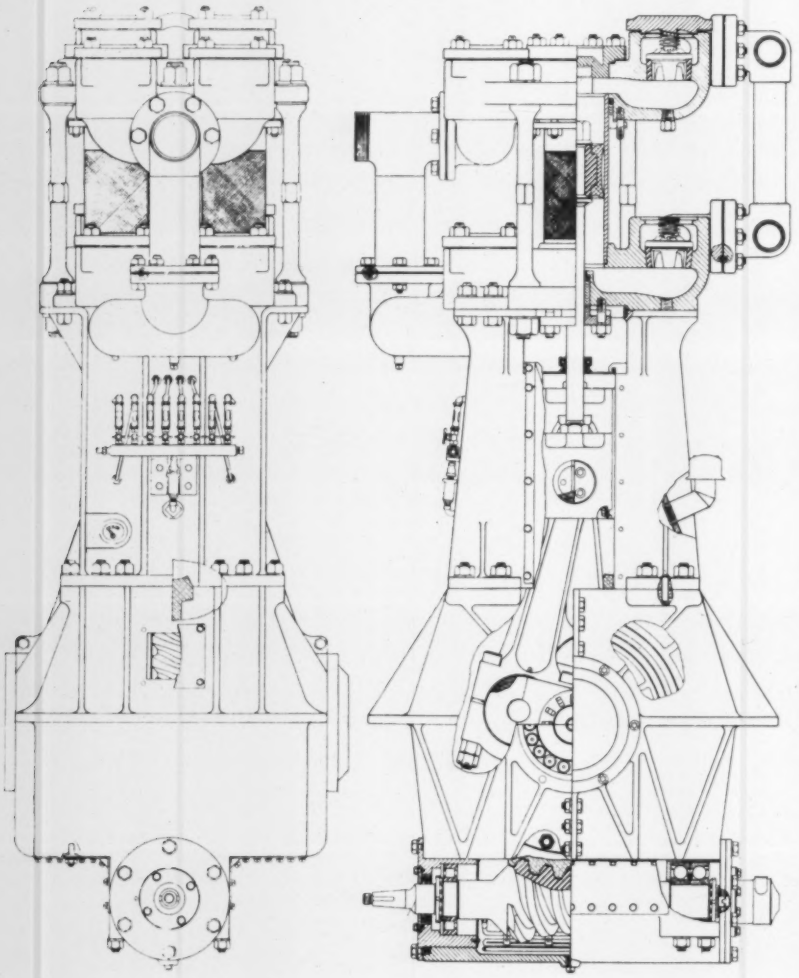


FIG. 1 VERTICAL CEMENTING PUMP

(Power-end housing, crankshaft, connecting rods, and crossheads, cast steel, S.A.E. 4335; crankshaft driven by Cone worm wheel, mounted between crank throws; crosshead shoes, bronze; crosshead guides, cast steel, S.A.E. 4635; liquid end in two sections with the interchangeable cylinders, in between, threaded into lower section and packed in the upper; valves, wing-guide type with conical steel-to-steel seats equipped with beveled rubber inserts; pistons, molded rubber on steel core.)

1 To operate against high pressures with fair volumes of fluid.

2 To have good throttle action.

3 To give dependable operation under rough usage.

4 To pump many different fluids including water, drilling mud, cement slurry, oil, and sometimes acids.

Current practice requires the use of two basic types of cementing equipment. Where steam is not available at the location, a power-driven unit is furnished; but where steam can be obtained from the drilling-rig boilers, steam pumps are used.

FIG. 2 MOTORIZED CEMENTING UNIT WITH VERTICAL CEMENTING PUMP

Two pumps are normally provided on the motorized units, one for supplying the water to the cement mixer and the other for pumping the cement slurry. The ordinary mixing pump is a vertical triplex plunger pump, having a capacity of about 250 gpm at 400 psi, and is direct-driven by a gasoline or Diesel engine. Smoothness of flow and good response to engine throttling are the particular requisites of the mixing pump. These pumps are usually stock types adapted to the truck mounting. The cement pump may be a stock-size, duplex, horizontal, double-acting, power pump, in areas where the service is not severe, or may be especially designed by the service company.

The steam unit usually carries three pumps, one to mix the cement slurry and either one or both of the others to pump the slurry into the well. The two cement pumps in parallel furnish high capacity and, compounded, are capable of high pressures. If cement is not being mixed, all three can be compounded to furnish maximum pressure. Most of the steam pumps are 10 × 4½ × 10 in. with liner reductions to 4 or 3½-in. bore. These units are capable of delivering a reasonable capacity against a pressure of 4000 psi. A new 12 × 4½ × 12-in. pump is described later.

VERTICAL CEMENTING PUMP

Progressively deeper drilling and the development of new cementing techniques caused the early power-driven pumps to become obsolete. The design of a vertical cementing pump, rated at 7000 psi, was completed in 1937 and production started early in 1938.

As shown in the two views of Fig. 1, the vertical cementing pump is a duplex, double-acting, packed-piston, power-driven type with 10-in. stroke and interchangeable cylinders 5, 4½, and 4 in. in diameter. The intermittent power rating is 120 hp with a minimum input-shaft speed of 185 rpm.

This pump, built into a cementing unit as in Fig. 2, is mounted on two cross members and extends downward between the rails of the truck chassis which are 30 in. apart. It is driven from the truck engine by a torque tube and universal joints extending from the power-take-off shaft of an amidships-type transmission. Using this system, the gearing of the transmission will vary the speed of the pump without materially decreasing the horsepower available and, in turn, vary the discharge volume to suit the pressure conditions of the work at hand. The truck engine may be one of two types—a Diesel engine of 108 hp at 1800 rpm, or a gasoline engine of 110 hp at 2200 rpm. The Diesel engine provides the better operation because of its slower speed, higher torque, and other inherent characteristics.

The completed vertical pump, ready for mounting on the truck, weighs 4350 lb. With 4½-in. pistons installed, its capacity ranges from 197 gpm against atmospheric discharge pressure to 25 gpm against 6000 psi discharge pressure. Equipped with 4-in. pistons, the pump is rated at 7000 psi but, in actual field use, has pumped against 8000 psi. Safety valves are not provided but the valve-pot cover studs are designed to fail at 9000 psi.

The advantages of vertical construction, somewhat resembling marine practice or mine- and sinking-pump design, are:

1 The power end can be placed between the rails of the truck chassis. This allows direct connections to the power-take-off shaft and at the same time places the fluid end in a position most convenient to the operator.

2 The entire pump is supported on two cross members in the truck frame by flanges across the power end. This eliminates the possibility of misalignment when the truck chassis stands on rough or uneven ground.

3 Sidesway during operation is completely eliminated—an important consideration when fluid measurements are being made from the truck tanks. Sidesway has been eliminated because all inertia forces of the reciprocating and heavy rotating parts and most of the vibration forces are opposed by vertical and longitudinal action of the truck springs. The crankshaft center line is parallel to the truck axles and the reciprocating parts move in a vertical plane.

4 The stress on the truck frame is limited to the torsional load between the truck engine and the power end of the pump.

5 The vertical pump is readily adapted for portable use. The center of gravity is 21 in. above the truck frame and only 30 × 37 in. floor space is required for mounting.

STEAM CEMENTING PUMP

The need for a new steam pump for the three pump steam units developed because of the same changing conditions which necessitated the vertical power-driven pump. Consequently a 12 × 4½ × 12-in. steam pump has been designed to replace the 10 × 4½ × 10-in. in common use.

This new steam-pump cementing unit is shown in Fig. 3. With one pump supplying the mixing water and the other two taking away the cement slurry, this unit has a capacity in excess of 50 sacks of cement per minute. Operating with 350 psi steam pressure these three pumps can be compounded to discharge against pressures as high as 8500 psi. The average operating speed is 60 rpm; however, test speeds in excess of 150 rpm have been reached when discharging water at atmos-

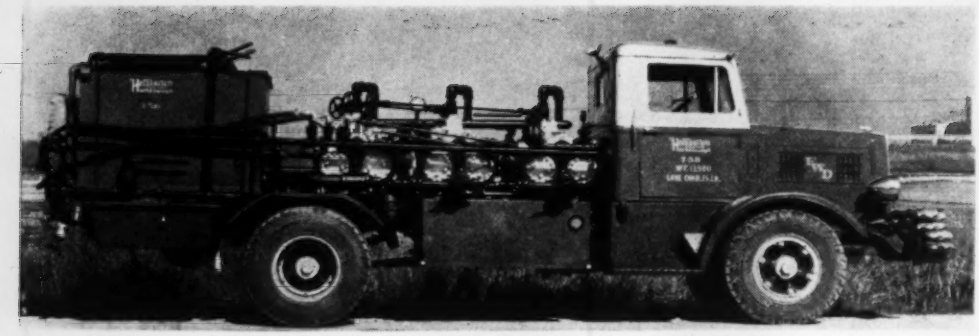


FIG. 3 THREE-PUMP STEAM CEMENTING UNIT
(Weight of chassis and body, 13,900 lb, gross weight, 26,500 lb.)

pheric pressure. In actual field operations speeds from 105 to 120 rpm have been maintained for considerable time when discharging mud at 1000 to 1500 psi. The fluid ends are shop-tested hydrostatically at a minimum of 10,000 psi and the test pressure frequently goes as high as 11,500 psi. The only safety device is the valve-pot cover gasket which fails at 11,500 psi. The suction side of the fluid end is shop-tested at 8000 psi to insure complete safety when operating under compound conditions. The length of the pump including the special discharge T fitting is $40^1/_4$ in. The weight is 2380 lb. Both length and weight are considered low for a pump of this capacity.

The valve motion on this pump is a unique device known as a "Volz motion." This device differs from the standard duplex pump valve motion in that each piston controls not only the motion of the opposite valve but also partially controls its own valve. This is accomplished by journaling the rocker shaft for each valve rod through an eccentric controlled by the piston rod of the opposite cylinder. Such arrangement has as its objective the making of the total valve area open at any one time equal to the area of one valve port fully open. This, in turn, tends to make the combined speed of both pistons at any given time equal to the maximum possible speed of either piston at the given throttle setting. The result is a smooth pump action as evidenced by the fact that discharge-pressure fluctuations for any given line pressure are about one half of those shown in the same pump with the standard duplex valve motion. It is claimed possible with the Volz motion to be able in a duplex double-acting pump to use three-ported valve cylinders. Tests have proved that such can be done but that more satisfactory operation comes from use of the standard five-ported valve cylinder. The particular advantage here in the use of the Volz motion is the ability of the pump to produce smooth discharge flow, excellent throttle action, and to work close to theoretical stalling pressure.

ACKNOWLEDGMENT

The author desires to express his appreciation to two former members of his staff, for assistance in preparation of the paper and collaboration in the design work described. These men are Lieut. James C. Traw, Corregidor, P. I., who could not be present because of international difficulties existing at that location; and Lieut. H. J. Crase, Fort Riley, Kan.

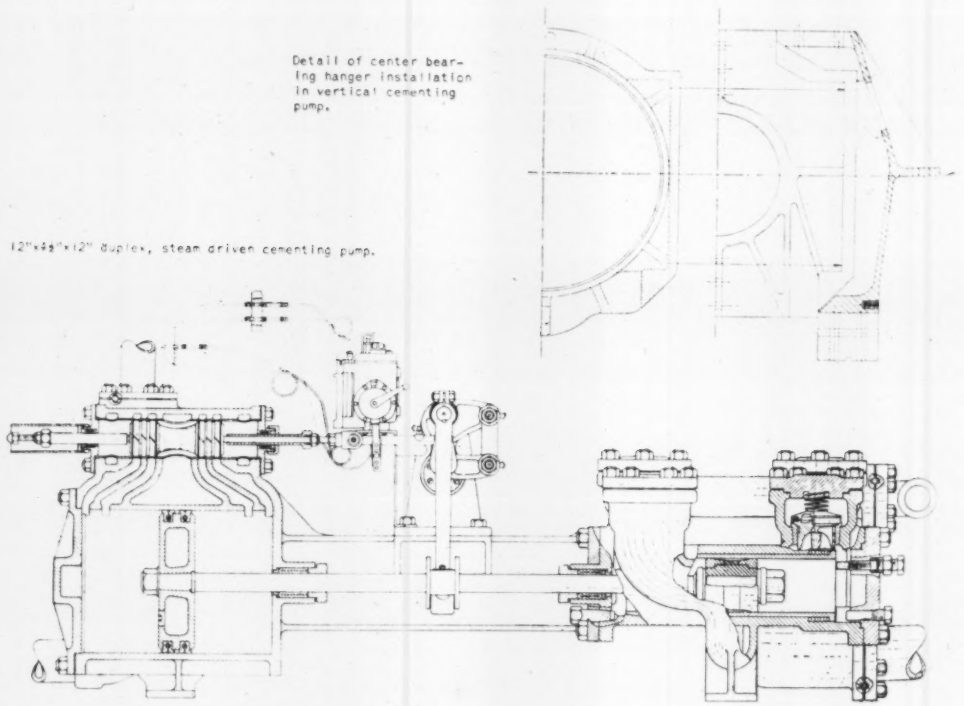

Detail of center bearing hanger installation in vertical cementing pump.
12"x4½"x12" duplex, steam driven cementing pump.

FIG. 4 DUPLEX STEAM-DRIVEN CEMENTING PUMPS, $12 \times 4^1/_2 \times 12$ IN.
(Steel cylinder liners, hardened and ground, are packed off at the head end, and on the opposite end are seated into a short tapered section; steam pistons, cast steel; T section segmental piston rings, the steam side of each ring is bronze and the other half cast iron; piston valves work within bores into which centrifugally cast molybdenum-iron liners are shrunk-fit; valves, nickel cast iron, fitted with three cast-iron rings on each end.)

Essentials and Substitutes

W.P.B BUREAU OF INDUSTRIAL CONSERVATION

THE first of a periodic series of provisional reports on the relative scarcity of certain materials was issued recently by the Conservation and Substitution Branch of the Bureau of Industrial Conservation, War Production Board.

The list is arranged in three groups according to the general availability of materials for substitution or use in civilian industry, and the Bureau emphasizes the fact that the status of the listed materials and others, as well, is constantly changing in relation to supply and demand. As a result, it is planned to issue similar reports at regular intervals to reflect changing conditions.

The first group is made up of materials that generally are critically essential for the prosecution of the war. For these materials civilian industry must largely find substitutions.

Materials listed in the second group are also necessary for war production and essential industrial activity, but the supply picture is not as right. Necessary civilian industry may obtain limited supplies from this group, it was noted, to replace unavailable materials, when specific cases are considered to be sufficiently important.

The third group includes materials that are more available for substitutions, although in no case, it was stressed, can the supply be considered unlimited, since other factors than the material itself may determine the amount available. The three groups of materials listed are as follows:

GROUP I

Materials most vitally needed for war purposes; not generally available for civilian needs.

METALS

Alloy steel
- Iron alloys
- Alloy steel
- Wrought iron

Aluminum
Aluminum scrap
Cadmium
Calcium-silicon
Chromium
Cobalt
Copper
Copper scrap
Iridium
Lead
Magnesium
Nickel
Tin
Tin plate and terne-plate
Tungsten
Tungsten (*High-speed tools*)
Vanadium

CHEMICALS

Alcohol
- Methyl

Chlorinated hydrocarbon refrigerants
Chlorinated hydrocarbon solvents
Chlorine
Diphenylamine
Formaldehyde
- Paraformaldehyde
- Hexamethylenetetramine and synthetic resins therefrom

Phenols
Polyvinyl chloride
Sodium nitrate (pure)
Toluene

MISCELLANEOUS

Agar
Asbestos (*long fiber*)
Burlap and burlap products
Cashew-nut shell oil
Corundum
Cotton linters
Graphite (Madagascar)
Hemp seed
Jewel bearings
Kapok
Manila fiber and cordage
Pig and hog bristles
Rubber, crude, and latex
- Chlorinated
- Synthetic

Shearlings
Silk
Silk waste
- Silk noils
- Garnetted and reclaimed silk fiber

Sperm oil
Tin cans
Titanium pigments
Tung oil

GROUP II

Basic materials that are essential to the war industries but whose supply is not as critically limited as materials of Group I.

Acetone
Ammonia (anhydrous)
Antimony
Arsenic
Barium carbonate
Beryllium-copper alloys
Borax
Calcium
Carbon tetrachloride
Camphor
Casein
Glaseine
Kraft paper
Citric acid
Cocoanut oil
Cork
Cotton duck
Cryolite
Diamonds (industrial)
Diamond dies
Flax
Fish-liver oils
Glycerine
Hides and leather
Iodine
Jute and products
Linseed oil
Manganese
Mercury
Mica splittings
Molasses
Molybdenum
Natural gas
Natural resins
Nylon
Parchment paper
Palm oil
Phosphorus
Platinum
Potassium perchlorate
Potassium permanganate
Quartz crystals
Quinine
Rape-seed oil
Rayon
Rhodium
Rubber (reclaimed)
Shellacs
Sisal
Steel, carbon scrap
Spirits, distilled
Sugar
Teak
Tanning materials
Tetraethyl lead
Titanium pigment
Vitamin "A" products
Wool
Zinc (all grades)

GROUP III

Materials available in some quantities for other than strictly war purposes. However, the use may be restricted by accompanying manufacturing limitations. Restrictions are commonly imposed, but supplies are not critically short, except in the case of iron and steel.

SUBSTITUTE MATERIALS

Asbestos (common)
Asphalt
Brick and tile
Cement
Ceramics
Clay
Coal and coke
Concrete
Cotton
Feldspar
Glass
Gold
Iridium (plating)
Lignin
Limestone and marble
Lumber and millwork
Mineral wool
Paper (except items under II)
Paperboard
Plywood
Salt
Silver
Slate
Sulphur
Wall board
Wood and products
- Wood flour
- Wood fibers
- Wood pulp

Materials available in varying amounts for substitutions.

Ammonia (aqueous)
Bismuth
Cellophane
Cottonseed oil
Gypsum and products
Hair (cow, horse)
Palladium
Petroleum products
- Crude oil
- Gasoline
- Lubricating oil
- Paraffin

Plastics (cellulose, acetate, butyrate)
Rosin
Ruthenium
Silicon and alloys
Soy beans and products
- Protein
- Oil

Turpentine
Uranium

War materials presently available for substitutions in critical civilian industry.

Basic low-carbon steel
Bessemer steel
Gray cast iron
Malleable iron

Pendulum Cars in Service

RAILWAY MECHANICAL ENGINEER

IN THE November, 1940, issue of MECHANICAL ENGINEERING a paper by Beemer, Lindvall, Stoner, and Van Dorn described the early experimental pendulum-type railroad passenger cars built by the Pacific Railway Equipment Company.

An article in the February, 1942, issue of *Railway Mechanical Engineer* describes three new pendulum cars of improved design recently delivered, one to the Atchison, Topeka & Santa Fe, one to the Great Northern, and one to the Chicago, Burlington & Quincy. These cars are all de luxe chair cars, or coaches, practically identical in size and structural design, the only difference being in interior arrangement.

The car body rests on soft-action coil springs which are recessed into the car structure on either side of the center aisle. These springs carry only vertical load and allow, within limits of safe stress, sufficient horizontal movement of the top relative to the bottom for all lateral and turning movements of the truck in normal service. Lateral movement of the car body floating on the main springs is restrained by control arms and links which act on the body above the center of gravity. The control arms are flat-leaf steel springs with progressive stops which give a variable spring rate for lateral motion so that the car floats about a center position with small restraint, equivalent to the action of very long swing hangers, and is brought to a yielding stop for large, lateral swings.

The longitudinal position of the truck is maintained by the thrust tube or "wagon tongue" which is anchored in rubber near the center of the truck frame and, at the other end, to the car underframe. The rubber mountings of the longitudinal tie permit lateral movement and angular movement of the truck on curves, and constitute barriers against noise transmission. The coil-spring suspension involves no sliding or rotating parts carrying the weight of the car. The elements which have been described replace the center plate, side bearings, bolster, chafing plates, bolster springs, spring plank, and swing hangers used in all standard passenger-car trucks.

The successful performance of the experimental trucks indicated that the journal springs should be relatively stiff. The journal coil springs are mounted just above the boxes, and are applied so that some lateral movement can take place between the journal boxes and the truck frame. This movement is permitted by rubber-and-steel vulcanized pads on the side of the pedestals which are deflected in compression to relieve lateral shocks. The arrangement of parts is different from that used on the experimental cars but the characteristics are the same. The truck frames are arc-welded, of high-tensile low-alloy steel, and are stress-relieved before machining.

PRINCIPAL DIMENSIONS, WEIGHTS, AND SEATING CAPACITIES OF NEW PENDULUM CAR

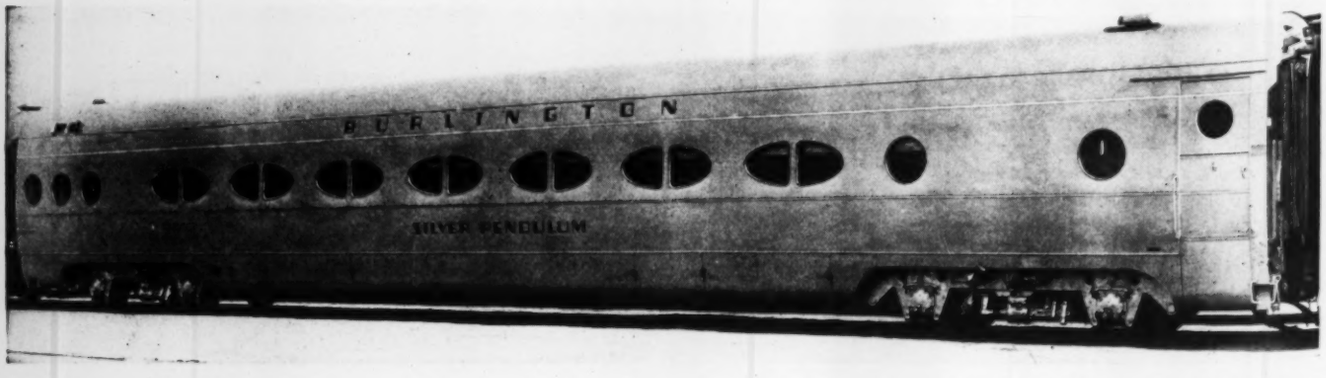
Salable seats:	
Santa Fe	56
Great Northern	68
Burlington	60
Coupled length, ft-in	85-0
Length over body end posts, ft-in	82-8
Length between truck centers, ft-in	60-0
Over-all width, ft-in	10-0
Inside width, passenger compartment, ft-in	9-5
Over-all height, ft-in	13-5
Inside height, passenger compartment, ft-in	8-1/2
Height of body suspension above rail, ft-in	7-3
Height of center of gravity above rail, ft-in	6-1
Truck wheel base, ft-in	9-0
Light weight of car, lb	109,000
Weight of two trucks, lb	31,000
Weight of body structure, lb	32,000
Weight of equipment and furnishings, lb	46,000

Eight body springs are used per truck, four on each side. These springs are mounted just above the frame side members and extend upward 26 in. within the body to the body-support structure. The static deflection of 10 in. together with the rubber insulator at the top of the springs with a deflection of 3/8 in. is said to insulate the car body thoroughly from disturbances in the truck. As in the case of the experimental car springs, considerable analytical and test work was performed in establishing correct relationships between static deflection, working height, and pitch diameter to obtain freedom of lateral movement and stability. In these springs, the greatest lateral movement encountered in normal service increases the working stress near the ends of the coils by 25 per cent.

The lateral springs consist of two plates clamped rigidly to the side of the truck frame extending between the body-support bulkheads to a point above the center of gravity of the body. Rubber-cushioned progressive lateral stops shorten the effective spring length with increased deflection, and thereby increase the spring rate with deflection. Lateral tie rods with rubber-mounted end connections attach the lateral spring to the car body at a point about 20 in. above the center of gravity of the entire body assembly.

Hydraulic shock absorbers, mounted on the side of the truck frame, are connected by means of long vertical tie rods, to the body structure. These two vertical tie rods, also used to hold the truck to the car body in case of derailment or overturning, are designed to meet the Association of American Railroads strength requirement. Hydraulic shock absorbers, mounted in the body-support structure, are connected by means of lateral links to the tops of the lateral spring housings which are rigidly attached to the truck frames at their lower ends.

Demonstration runs indicate that the new pendulum cars are



Courtesy Railway Mechanical Engineer

FIG. 5 PENDULUM CAR RECENTLY DELIVERED TO THE C.B.&Q.

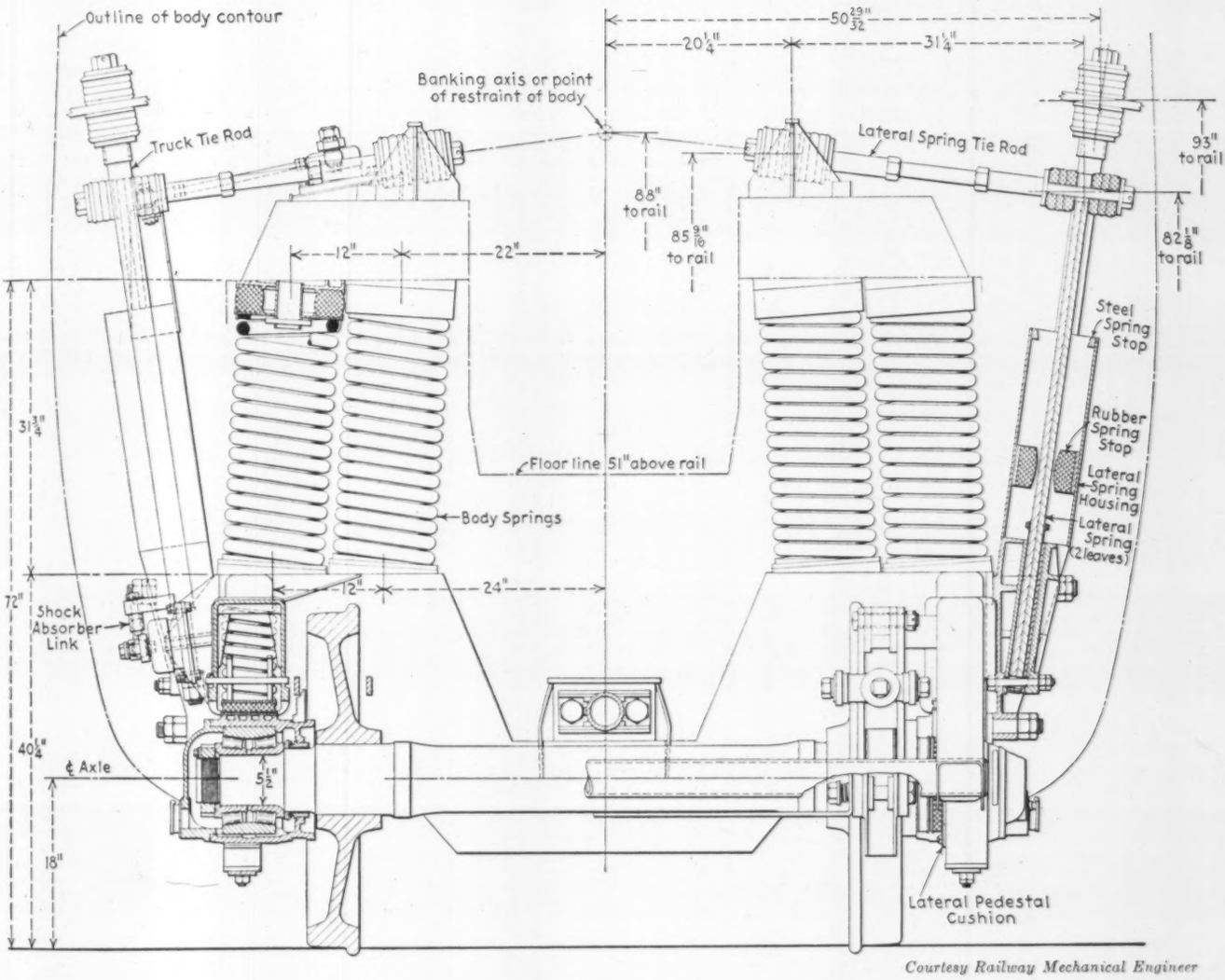


FIG. 6 PARTIAL CROSS SECTION OF PENDULUM CAR THROUGH TRUCK-SPRING SUPPORT

unusually quiet and that the riding qualities represent a distinct improvement over existing modern equipment. Although this type of car rides well when coupled to standard cars, the best riding qualities and full action of the pendulum suspension can be experienced only when the car is coupled between other cars of similar design. Since the banking of the pendulum car is opposite in direction to the roll of a standard car there is more relative movement, and greater forces act at the diaphragm when the pendulum car is coupled to a standard car than when coupled between other pendulum cars. While these forces restrict the pendulum action and tend to introduce some shock and vibration into the car, the generally excellent riding qualities are apparent to passengers comparing this car with other cars, even when the car is coupled between standard cars.

Degassing Molten Aluminum

THE ENGINEERS' DIGEST

APPEARING in *The Engineers' Digest* for January, 1942, is the following abstract entitled "Degassing of Molten Aluminum Alloys by Vibrations Produced by Electromagnetic Fields." The original article is by Th. Rummel and was taken from *Zeitschrift des Vereines deutscher Ingenieure*, vol. 85, no. 24, June 14, 1941, p. 548.

Molten metals generally contain considerable quantities of gas in solution. This has the undesirable consequence, especially with aluminum and its alloys, that cavities and pinholes are formed when the metal solidifies, which lower the strength and the ductility of the material.

Recently, electrically produced vibrations have been successfully applied for degassing aluminum and its alloys. A most difficult question has been how to transmit the energy of vibrations of acoustical frequency to the molten metal. Besides the great losses of energy, which occur with the transmission, finding a body suitable to be immersed into the molten metal in order to transmit the vibrations presented a problem, the solution of which seemed not to exist. However, this difficulty has been overcome by producing the vibrations within the molten metal by electromagnetic fields.

For the experimental development of the new procedure quantities of 10 kg of molten metal were used, contained in a crucible placed within a coil according to the usual arrangement in high-frequency furnaces. This coil was fed simultaneously by direct current, producing a stationary magnetic field, and by alternating current of medium frequency (about 1000 cycles). In the outer circuit these currents were appropriately separated.

By the interaction of the static magnetic field and the high-frequency currents induced in the molten metal, oscillating forces are exerted on each particle of the bath, proportional to the product of the magnetic field and the induced currents, and directed radially to and from the axis of the coil. The mechanical vibrations thus produced in the molten metal can be amplified by resonance.

It has been found possible to remove by this procedure all the gas included in molten aluminium or aluminium alloys in less than half an hour.

More Magnesium

MINING AND METALLURGY

IN A paper presented in the "Ores, Metals, and the War" symposium of the annual meeting of the A.I.M.E., Philip D. Wilson of the War Production Board described methods and processes of "Enlarging Magnesium Output a Hundredfold."

The author traces the development of the electrolytic processes of magnesium production using the Dow cell and the cell of Magnesium Electron, Ltd., and gives information on the various plants, both productive and under construction, which are to furnish the major part of the magnesium manufactured in this country. Included in the electrolytic group is a new government plant to be operated by the Mathieson Alkali Works, Inc., which will use a new type of cell recently developed. This cell has the advantage in that concentrated chlorine gas, a critically valuable material, is produced as a by-product. That it will require slightly less electric current per pound of magnesium is indicated by pilot-plant operation. The total electrolytic portion of the original pre-Pearl Harbor program is scheduled to use over 500,000 kw of connected power for 167,000 tons of metal per year.

Representing the thermic-reduction processes are the Hansgirg carbothermal and Dr. Pidgeon's ferrosilicon methods.

A few months ago, according to Mr. Wilson, Henry J. Kaiser was inspired by an Austrian scientist, Fritz J. Hansgirg, to build, with his own funds and R.F.C. credit, a plant at Permanente, Calif., to exploit the carbothermal reduction of calcined magnesium oxide. The Hansgirg process had been tried in Austria, England, and Japan with somewhat indifferent success. The Permanente plant produced its first high-quality metal last October and Kaiser has arranged to double his original plant at his own expense to a total estimated annual capacity of 24,000 tons of magnesium.

Briefly, a mixture of coke and calcined magnesia is heated in an electric-arc furnace to a temperature of about 2100 C. The vaporized metal is "shock-cooled" with natural gas, and the finely divided magnesium is separated from the gases by Cottrell precipitators. This powder, contaminated with carbon and some oxide which has flashed back before cooling, is mixed with oil and the doughy mixture redistilled. The oil goes over first and finally the magnesium, condensing as crystals of high purity.

When it became evident that power requirement would be the limiting factor in the electrolytic production of magnesium, a committee of the National Academy of Sciences investigated the processes other than electrolytic which appeared to have merit. The Academy committee, continues Mr. Wilson, recommended unreservedly the ferrosilicon process, in which calcined dolomite is mixed with and reduced by pulverized ferrosilicon at a temperature of about 1150 C.

The reaction takes place in a vacuum and is positive and direct. The vaporized magnesium condenses as a metal of high purity in the water-cooled section of the furnace or retort. Heat can be furnished by electricity or gas and even where the former is used considerably less power is required per pound of magnesium than in electrolysis. The other attractive features of the process are the speed with which a plant can be erected and the fact that the essential raw material, dolomite, is so widespread. Pilot-plant work on this process has been carried on concurrently during the last three years by three groups, the Union Carbide Co. and the Ford Motor Co. in the United States, and for the Dominion Magnesium Co., Ltd., by Dr. Pidgeon in Ottawa.

The author states that arrangements are being made with Dominion Magnesium so that qualified companies in the United States may use Dr. Pidgeon's process if they wish. Union Carbide, American Metal, New England Lime, and Ford have agreed to undertake portions of the new program; the latter has already started to build. Negotiations are also being conducted with others who want to participate. Present plans contemplate that about half the new expansion will utilize the ferrosilicon process.

Since one pound of 75 per cent ferrosilicon or its equivalent is required per pound of magnesium produced, substantial new ferrosilicon production capacity will have to be provided, which requires a complete new ferrosilicon construction program. Again the problem of power is a serious one. Some of the new plants will have to be installed where power can come only from civilian curtailment. Substantial quantities of nickel and chromium, both extremely critical today, must be provided for the Nichrome steel retorts and furnaces. But it is believed that these difficulties can be overcome and that substantial magnesium production will be coming by the ferrosilicon route by midsummer.

Thus to summarize the provisions for the greatly enlarged magnesium program, most of which will come in during 1942, about 70 per cent will be produced electrolytically, something over 20 per cent by the ferrosilicon process, perhaps 7 per cent by the Hansgirg carbothermal method, and the remaining 3 per cent by what must be considered semiexperimental processes. Of these the electrolytic is certainly the surest and safest, but it requires much electric power and the plant is slower and more expensive to build. The ferrosilicon process has had no such long record of commercial application, but it seems to be certain and rapid with a low capital cost per pound of production. Within the next six months it is hoped to have magnesium pouring from the ferrosilicon plants now being started. By early 1943 this huge expansion program is scheduled for completion, and magnesium-metal production for next year may well be more than one hundred times that of 1939.

Welding Instruction Films

IN MECHANICAL ENGINEERING for March, 1942, p. 204, there appeared a photograph of arc welding taken from a training film produced by Raphael G. Wolff studios.

Announcement has since been made that the Visual Instruction Section of General Electric Company has taken over this 16-mm color-film series, "Inside of Arc Welding," for noncommercial distribution to schools and other instruction groups to speed up war-production training.

The first picture in the series, titled "Fundamentals," was recently completed at the Wolff studios in Hollywood. Five additional subjects, all in 16-mm color, are now in final script, and it is planned to complete the series by June.

The series, it is said, will furnish a well-rounded comprehensive visual instruction course, illustrating in detail each step of the welding process with charts and diagrams as well as actual photographic action.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Chrome-Hardening Cylinders

COMMENT BY LEE SCHNEITTER[1]

In this paper,[2] considerable data are given on cylinder-liner wear to show the advantages of chrome-hardened surfaces. However, the author made only brief reference to material for piston rings. The writer's experience has indicated that wear of two separate irons or alloys of different hardness and structure is determined by the hardness and structure of their mating surfaces. Liners with 260 Bhn and upward show less wear in certain cases but often at the expense of the contacting part.

Some interesting wear-test data of various liner materials have been revealed in a paper by Paul Lane.[3] Various liner materials were run against cast iron, as used for conventional piston-ring structures. Wear of certain liner and ring materials, in terms of weight loss, was reported as follows:

Liner material	Brinell	Liner wear	Ring wear	Total
Plain cast iron	200–230	15.0	56.7	71.7
Alloy cast iron (heat-treated)	235	10.4	103.5	113.9
Alloy cast iron (heat-treated)	410	12.5	81.0	93.5
Nitri cast iron	800–1000	5.4	141.0	146.4
Chrome moly, S.A.E. 4140	320	4.2	61.6	65.8
Molybdenum steel, S.A.E. 4345	350	3.5	135.0	138.5
Nitralloy steel	975–1000	2.8	65.2	68.0

Does the author have data to offer concerning the kind of piston-ring material best suited to the hard chrome surface produced by his process; in other words, is it possible to use a ring-liner combination which will give low total wear?

AUTHOR'S CLOSURE

Several questions pertaining to the roundness of cylinders after commencing the polishing operation; to the thickness of the cylinder wall; and to the control of uniformity were asked by P. B. Jackson.[4] The answer is that there is no control. Dimensional control is obtained by the electroplating and final finishing. The surface finish is a matter of judgement based on experience, and it can be controlled by honing and checked with the profilometer.

A. B. Willi[5] inquired as to the most favorable thickness of chrome plating which should be applied to crankshaft pins and journals. Hundreds of crankshafts, especially on Diesels for locomotives, have been so finished, but not in this country. Right or wrong, on the crankshafts in question we applied 0.006 in. of chrome plating to the diameter. It may have been that 0.004 in. or 0.008 in. would have been equally good, but in the 0.006-in-thick plating no wear was ever indicated. Actually, there was some reason for the thickness of 0.006 in. selected. In early experience with chrome plating, it was found that a thickness of 0.002 in. would corrode down to the core, under fairly stringent test conditions. By adding another 0.001 in. to that, the proper protection for the shaft was achieved. Chromium may be applied to a crankshaft within the limits, but should not be ground or otherwise finished. It should, however, be inspected.

A. K. Antonsen's[6] understanding that the larger the cylinder bore the heavier should be the layer of chromium plating is quite correct. He asked the specific question: "How heavy should the plating be on a 20-in-bore cylinder, and how heavy on a 3-in. cylinder? In answering this question, it must be realized that large cylinders of large engines are expected to have much longer life than those on smaller engines. An automobile engine never lasts longer than 2000 hr, while 2000 hr in the case of a motorship is still within the period of guarantee; the engine is supposed to be still new. Owners want 40,000 or 50,000 hr, so naturally since chromium also wears, a thick coating must be used. Usually, in the smaller engines, let us say under 6 in. bore, a coating thickness of 0.008 in. is sufficient to last the lifetime of the engine. This expressed in terms of a truck engine means 300,000 or 400,000 miles.

W. L. H. Doyle[7] is interested in knowing whether the porosity which is featured should be continued through the plating and to the base iron, and whether or not data are available on the change in the coefficient of friction with the change in the character of porosity. The answer to this question is that it is preferable for the porosity to extend about half way through the plating. Care must be taken that the porosity does not extend all the way down to the base metal, because the coating should be a fair protection against rust. This is especially so in airplane engines, where the use of doped fuel causes cylinders to rust after having been in use. The author has found that the additional feature of a coating of chrome as a rust preventative is welcome in Diesel engines too, particularly in stand-by engines.

As regards the effect of porosity on coefficient of friction, it is believed that the porosity gives a much smaller actual surface area in the cylinder; there are many pockets where the rings do not touch, and these are filled with oil. Without knowing for sure, it would be assumed that the porous cylinder has less friction than a cylinder with a solid chrome coating.

Mr. Schneitter says no reference is made to material for piston rings, but apparently he missed that small part in the paper, which reads as follows:

"Regarding piston rings, all makes of rings may be used with one definite exception. Chrome-hardened rings should not be run on chrome bores; nor should nitrided rings or other very hard rings be used. Experience shows that chrome-hardened and nitrided rings cause scoring

[1] Diesel Engineer, Ebasco Services, Inc. New York, N. Y. Mem. A.S.M.E.

[2] "The Chrome-Hardening of Cylinder Bores," by H. Van der Horst, MECHANICAL ENGINEERING, vol. 63, 1941, pp. 536–539, and 542.

[3] "Bore Wear From the Viewpoint of Materials," by Paul S. Lane, Trans. S.A.E., vol. 34, 1939, pp. 413–420.

[4] Aluminum Company of America, Cleveland, Ohio.

[5] Chief Engineer, Federal-Mogul-Corporation, Detroit, Mich. Mem. A.S.M.E.

[6] Menasco Manufacturing Company, Burbank, Calif.

[7] Research Engineer, Caterpillar Tractor Company, Peoria, Ill. Mem. A.S.M.E.

of the bore, the piston, and the rings in a very short time."

Only recently the author has had experience which indicates that piston rings with bronze inserts do not do too well either. Also, some uncertainty exists in the case of tin-plated rings. It can be stated that in more than 100,000 engines with chrome-hardened bores now in use, ordinary straight cast-iron rings are used.

Mr. Schneitter indicates that if one part is hard and shows low wear, the contacting part wears so much more rapidly. This is definitely not the case with a chrome liner, which may have 1150 Bhn, and cast-iron rings of 200–260 Bhn. If Mr. Schneitter will examine Fig. 1 in the paper, he will notice that the ring wear on the chrome bore is only one fourth that of the ring wear on the cast-iron bore, both sets of rings being exactly the same.

Expressed in figures, calling the wear of the chrome bore 10, we have the following comparison between the two materials:

Liner material	Brinell	Liner wear	Ring wear	Total
Chrome-hardened cast iron	1150	10.0	86.1	96.1
Cast iron.....	241	70.8	319.0	398.8

These figures, of course, cannot be compared with Paul Lane's[3] as his tests were made on a wear-test machine, while the author's are actual engine results.

In response to V. L. Maleev's[8] question, concerning the possibility of replating cylinder liners without removing the old plating which has not entirely worn off, it may be said that chromium should never be deposited on existing chromium because this will result in an insufficient bond. Therefore the old chrome should be stripped off by electrolysis, reversing the flow of current. Then the cylinder must be honed and after that it can be replated.

H. VAN DER HORST.[9]

[8] Research Professor of Mechanical Engineering, Oklahoma A. and M. College, Stillwater, Okla. Mem. A.S.M.E.

[9] Van der Horst Corporation of America, Olean, N. Y.

Subordinate Personnel

COMMENT BY G. K. BENNETT[10]

This paper[11] is representative of sound psychological opinion upon the topic of selection. Psychology, like any other science, must rely upon experimental findings as the basis for its claims. In the development and evaluation of tests and other selective devices, psychologists have available an extensive methodology which permits determination of the extent to which any one of these instruments succeeds in its function. There are, unfortunately, many persons who prepare and sell selection methods which have not been adequately tested, either because their author was ignorant of these methods or because he was afraid disinterested scrutiny would reveal the defects of his product. It is comparatively easy to recognize these since the claims made for them resemble those made for patent medicines. No one test or system can be a panacea and no sound industrial psychologist will make statements of that sort.

Turning to the positive aspects of test applications, the writer would like very briefly to expand upon the author's remarks. Let us take a situation which is quite common today; that of a manufacturing company which is expanding both its plant and personnel. It is no longer possible to hire new men with experience, and training time for the inexperienced must be held to a minimum. Assuming that competent industrial engineers have arranged for the maximum utilization of present personnel, how can psychological selection methods aid this company?

1 By determining from job analysis the requirements of each job title and translating these into definite terms of years of education or test scores.

2 By establishing a systematic procedure for determining the extent to which each applicant possesses the desired characteristics.

3 By instructing the employment division in the use and interpretation of the tests employed and making periodic checkups on the operation of the program, so that it may be kept adjusted to changing conditions.

Very frequently the use of these measures permits us to select highly suitable employees from groups previously considered ineligible because of lack of training or experience. Superior mechanical talent may be found among office workers, salesmen, and truck drivers. College level intelligence is possessed by many who have not completed high school. The use of a properly designed test battery has the further virtue of identifying those who have capacity to progress beyond the beginning-level jobs and to profit rapidly from experience.

Neither education nor experience can guarantee us uniform material for employment, but available tests can eliminate those who cannot learn rapidly and can help to select those of unusual ability.

COMMENT BY C. I. HOVLAND[12]

The basic theoretical principles underlying employee selection have been excellently analyzed in this paper. It must certainly be clear from the author's remarks that psychological testing in industry does not rest upon magical and esoteric formulas; instead, the same rigorous scientific methods are employed here which have been so brilliantly applied in engineering.

Our own experiences in using psychological testing techniques in personnel selection have abundantly confirmed the observations reported by Taylor. A few illustrations will be mentioned which may be of interest to this group.

For some time we have been interested in the possibilities presented by the planned interview which Taylor discussed. The writer was especially glad to hear him dispel some of the misconceptions commonly held concerning this technique. The contention sometimes made that such a procedure is too routine, mechanical, and artificial is based on a misunderstanding concerning its application. The planned interview does not change the role of the interviewer; it does not eliminate the need for skillful and courteous interviewing. It merely provides, as the name suggests, a planned outline of the material, obtainable in an interview, which is most relevant to an evaluation of the capabilities of an individual for a particular job. The details involved in obtaining this basic information, the phraseology, sequence of questions, etc., are determined by the interviewer, and here he expresses his own ability and personality.

In a large organization, the planned interview is particularly helpful because it makes possible comparability between the evaluations of various interviewers. We have also found the planned interview a splendid basis for training new men in interviewing technique. We have gone beyond the usual planned interview in a standardized interview outline which we employ, called the "Diagnostic Interviewer's Guide." This form not only provides for obtaining the necessary information concerning the applicant in an orderly fashion, but also permits a rating by the interviewer of the present capa-

[10] Director, Test Division, Psychological Corporation, New York, N. Y.

[11] "The Selection of Subordinate Personnel," by H. C. Taylor, MECHANICAL ENGINEERING, November, 1941, pp. 807–810.

[12] Department of Psychology, Institute of Human Relations, Yale University, New Haven, Conn.

bilities and future potentialities of the applicant, as judged by his answers to questions asked during the interview. Separate sections of the blank cover work, family, social, and personal history. The total evaluation of the applicant by the interviewer (obtained by summing the scores on the separate items) provides a reliable and valid prediction of future success.[13]

The types of formal employment tests which we have found most useful for office and other "white collar" jobs have been those of mental ability and of personality. After extensive analysis and standardization it is possible to obtain, in a period as short as twelve minutes, a picture of an individual's mental ability which will forecast his performance on the job, in the "test of life itself." In one organization we found that our mental-ability test (The Personnel Test) would permit us to select a minimum score, such that 78 per cent scoring below that point resigned or were dismissed within a year, while only 18 per cent scoring above that point resigned or were dismissed within the same period.[14]

Another type of employment test not mentioned by the author which we believe to be extremely useful for jobs involving personal contact is one of personality and interests. An analysis of how successful men differ from unsuccessful reveals that there are differences in attitudes, likes, and dislikes which give us clues at the time of employment which are predictive of future success. By weighting these items properly, future success or failure can be predicted with considerable accuracy. Our experiences with this type of test are discussed in the Moore reference cited in Taylor's paper.

The author raises a very interesting question in asking whether it is not possible to make tests more immediately available for present needs. It is perfectly true that there are many organizations employing men without tests for occupations closely similar to those for which tests have been successfully developed by other companies. In many of these situations, it would be possible to administer tests with a minimum of new standardization. However, it has been the writer's experience that this is a risky procedure. Organizations, like individuals, require a considerable period of time to become sufficiently familiar with the uses of tests to evaluate them properly and to avoid the extremes of skepticism on the one hand and overoptimism on the other. If the period of time required to attain this familiarity can be reduced by education in the uses and abuses of tests, and if you will give the test constructor your confidence, let him apply his results with necessary cautions, and do not ask for immediate dramatic results, there is reason to believe considerable progress in this direction can be achieved.

[13] "Prediction of Industrial Success From a Standardized Interview," by C. I. Hovland and E. F. Wonderlic, *Journal of Applied Psychology*, vol. 23, 1939, pp. 537–546.

[14] "The Personnel Test: A Restandardized Abridgment of the Otia S-A Test for Business and Industrial Use," by E. F. Wonderlic and C. I. Hovland, *Journal of Applied Psychology*, vol. 23, 1939, pp. 685–702.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Committee Secretary, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all of the members of Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting of the Committee.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of February 20, 1942, subsequently approved by the Council of The American Society of Mechanical Engineers.

CASE No. 890

(Annulled)

CASE No. 931 *(Reopened)*

(Special Ruling)

Inquiry: In view of the present emergency that makes it practically impossible to obtain certain materials made in accordance with Code specifications, may materials available in jobbers' stocks or elsewhere be used in Code boilers and other vessels?

Reply: It is the opinion of the Committee that, as a temporary expedient, material as covered by Specifications S-5, S-7, S-11, S-13, S-15, S-16, S-17, S-18, S-19, S-23, S-24, S-40, and S-49, but for which mill test reports or other evidence of compliance with the specifications are not available, may be used provided samples of such material are tested as to physical and chemical properties and shown to be in substantial compliance with the appropriate specifications applicable to the purpose for which the material is to be used, and the material shall be acceptable to the inspector.

CASE No. 959

(Special Ruling)

Inquiry: The present national emergency renders it desirable to use universal or strip mill plate in certain sizes that can be produced by this process. Can such material be used as meeting the requirements of the plate specifications in the Code and what modifications in bend test requirements will be permitted?

Reply: It is the opinion of the Committee that such plates not over $^3/_4$ in. in thickness may be used during the emergency when conforming to Specifications S-1, S-2, S-42, or S-53 with the bend test requirements modified to meet those for universal mill plate in Par. 9 of Specification S-1.

CASE No. 960

(In the hands of the Committee)

CASE No. 961

(In the hands of the Committee)

CASE No. 962

(In the hands of the Committee)

CASE No. 963

(Interpretation of Par. U-36)

Inquiry: May a spherically dished head (so-called basket type) be made of two plates with a welded diametral joint, the thickness of the head being calculated in accordance with Par. U-36(a), without using the welded joint efficiency factor?

Reply: It is the opinion of the Committee that if the welded joint conforms with the requirements of the welded longitudinal joint of the shell and any openings are reinforced in accordance with Code rules, a head fabricated as indicated in the inquiry will meet the intent of the Code.

Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place in the code.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the code, and are submitted for criticism and approval from anyone interested therein. It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in small capitals; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

Preambles to the Codes. Revise first sentence of the Foreword to read:

In 1911 The American Society of Mechanical Engineers appointed a committee to formulate standard specifications for the construction of steam boilers and other pressure vessels and for their care in service, which committee has since come to be known as the Boiler Code Committee.

Add the following to the preamble:

The Code does not contain rules to cover all details of design and construction. Where complete details are not given, it is intended that the manufacturer, subject to the approval of the authorized inspector, shall provide details of design and construction which will be as safe as otherwise provided by the rules in the Code.

PAR. P-101. Change the word "specifications," which is the first word of the seventh line, to "provisions." Delete all of the second sentence relative to superheater headers.

PARS. P-102(*b*) AND U-68(*b*). Replace first section by the following:

All longitudinal and circumferential welded joints shall be radiographically examined throughout their entire length, except as provided in Pars. P-112 and P-268(*o*) (U-71*b* and U-59*o*).

PAR. P-108. Revise first sentence of (*a*) to read:

P-108 *Stress Relieving.* (*a*) All fusion-welded pressure parts of power boilers shall be stress-relieved except as provided in Par. P-112.

(*b*) and (*c*) to remain unchanged, but under (*c*) add another item as (4), as follows:

(4) Nozzles or other welded attachments for which stress relief is required may be locally stress-relieved by heating a circumferential band around the entire vessel with the connection at the middle of the band, the band width to be at least 12 times the shell thickness wider than the attachment, an in such a manner that the entire band shall be brought up to the temperature and held for the time specified above for stress relieving.

PAR. P-109. Revise to read:

P-109 *Hydrostatic Tests.* (*a*) All fusion-welded drums and other pressure parts, excepting fire-tube boilers which need only be tested under Par. P-329, shall be subjected to a hydrostatic test pressure of 2 times the maximum allowable working pressure as determined by the formula in Par. P-180 using the design dimensions and plate thicknesses of the parts and the "*S*" value permitted for atmospheric temperature.

Delete present (*b*) and (*c*), relettering present (*d*), (*e*), and (*f*) as (*b*), (*c*), and (*d*).

PAR. P-112. Revise (*a*) to read:

Welded Connections. (*a*) Circumferential joints of pipe, tubes, superheater headers, waterwall headers, or economizer headers may be fusion-welded within the following limiting conditions and as provided in this paragraph:

(1) When the parts to contain steam do not exceed 16 in. nominal pipe size or $1^{5}/_{8}$ in. wall thickness, or the parts to contain water do not exceed 10 in. nominal pipe size or $1^{1}/_{8}$ in. wall thickness. In each case the welds shall not be in contact with furnace gases.

(2), (3), and (4) to remain unchanged. In (5) delete clause reading: "the end of the pipe before welding is not less than $^{1}/_{16}$ in. from the bottom of the socket."

(6) Parts mentioned in (*a*), exceeding the dimensions given in (1), (2), and (3) above, may be fusion-welded under the requirements of this paragraph provided the welded joints are radiographed and meet the requirements of Par. P-102(*b*).

Revise (*d*) to read:

(*d*) Welding procedures and welding operators shall have been qualified in accordance with the provisions of Section IX.

The tests conducted by one manufacturer shall not qualify a welding operator to do work for any other manufacturer. No production work shall be undertaken by an operator until both the process and the operator have been qualified.

Pipe connections up to $^{1}/_{2}$ in. pipe size may be welded to pipe under the provisions of this paragraph without Code inspection.

PAR. P-113. Revise to read:

P-113. Superheater, water wall, or economizer tubes, complying with any of the specifications for tubes given in Par. P-103(*a*), may be fusion-welded to tubular manifolds, headers, or drums without being expanded. The welds shall be strength welds similar to Fig. P-36(*c*), and shall be stress-relieved. Radiographic examination is not required. A hydrostatic test shall be made at twice the working pressure subject to any necessary modifications due to temperature requirements in accordance with Table P-7.

PAR. P-246(*a*). Revise to read:

(*a*) The cast iron used for headers of water-tube boilers shall conform at least to Class 25 Specification S-13 for Gray-Iron Castings. The malleable iron used for headers of water-tube boilers shall conform to Specification S-15 for Malleable-Iron Castings.

PARS. P-195(*a*) AND U-36(*a*). Revise formula to read:

$$t = \frac{1.67\,PL}{6SE}$$

where S = maximum allowable working stress, as given in Tables U-2 or U-3 (P-7), lb per sq in.
E = efficiency of weakest joint used in forming the head, including the joint to the shell;
for riveted joints = calculated riveted efficiency,
for fusion-welded joints = efficiency specied in Par. P-102,
for seamless shells with integral heads = 100 per cent

Omit definition for *TS* but retain all other definitions.

PARS. P-195(*m*) AND U-36(1). Revise formula to read:

$$t = \frac{PL}{2SE}$$

where S = maximum allowable working stress, as given in Tables U-2 or U-3, P-7, lb per sq in.

Delete definition for *TS*.

PAR. P-250(*a*). Add the following:

Tube ends not subjected to direct radiant heat of the furnace may be rolled and seal welded without beading provided:

(1) The tube ends extend not less than $^{1}/_{4}$ in., nor more than $^{5}/_{16}$ in., through the tube sheet;

(2) The throat of the seal weld is not less than $^{3}/_{16}$ in., nor more than $^{5}/_{16}$ in.;

(3) After welding the tubes are re-expanded.

PAR. P-251. Add the following to the first sentence of the first section:

or flared, rolled and welded except as provided in Par. P-113; or rolled and seal-welded without flaring, provided the throat of the seal weld is not less than $^{3}/_{16}$ in., nor more than $^{3}/_{8}$ in., and the tubes are re-expanded after welding.

Insert the following as the second sentence of the first section:

Tube ends or weld necks may be fusion-welded in accordance with Par. P-112 to the drums of water-tube boilers without expanding or flaring provided the materials and welding comply with Pars. P-101 to P-110, inclusive, except that the test-plate requirements of Par. P-102 may be omitted, and the connections comply with Par. P-268.

PAR. P-281(*a*). Add the following:

Safety valves used on forced-circulation boilers of the once-through type may be set and adjusted to close after blowing down not more than 10 per cent of the set pressure. The valve for this special use must be so marked when adjusted by the manufacturer.

PAR. P-291. Revise first section to read:

P-291. Water Glasses. Each boiler shall have at least one water gage glass except that boilers operated at pressures over 400 lb per sq in. shall be provided with two water gage glasses on the same horizontal line with separate connections at least 2 ft apart or may be corrected to the same water column. When the distance from the boiler shell is less than 6 in., the pipe connection shall be not less than $1/2$ in. pipe size. Each water gage glass shall be equipped with a valved drain.

PAR. P-294. Revise to read:

P-294. Gage Cocks. Each boiler shall have three or more gage cocks located within the visible length of the water glass, except when the boiler has two water glasses, located on the same horizontal lines.

Boilers not over 36 in. in diameter in which the heating surface does not exceed 100 sq ft need have but two gage cocks.

PAR. P-299(*b*). Revise the first section to read:

The thickness of all fittings or valve bodies subject to pressure shall be not less than that required by the American Standard for the corresponding maximum allowable working pressure AND temperature FOR [and] the material used; except that in order to provide equal thicknesses for welding, the cylindrical ends of cast steel welding-end valves and fittings may be proportioned with a quality factor of 100 per cent provided these areas are finish-machined both inside and outside and ARE carefully inspected. In no case, however, shall the thickness of the ends be less, NOR MORE THAN 15 PER CENT GREATER, than that of the adjoining pipe. The machined ends MAY [shall] be EXTENDED BACK IN ANY MANNER PROVIDED THE LONGITUDINAL SECTION COMES WITHIN THE MAXIMUM SLOPE LINE INDICATED IN FIG. P-39$1/2$. THE TRANSITION FROM THE PIPE TO THE FITTING AT THE JOINT SHALL BE OF A SHAPE AVOIDING SHARP RE-ENTRANT ANGLES AND ABRUPT CHANGES IN SLOPE. [tapered on a 1:4 maximum slope for a distance measured from the center of the weld of approximately $1\frac{1}{2}$ times the pipe wall thickness. The remaining tapered section may be cast or machined on a 45 deg maximum angle.]

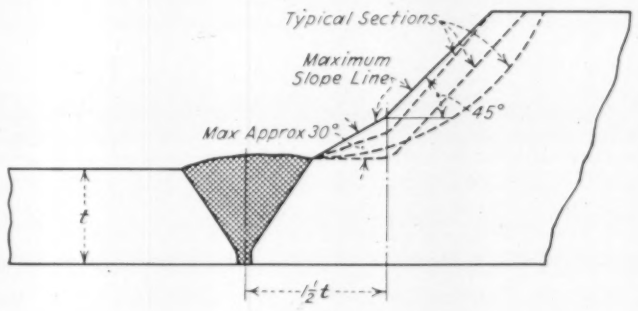


FIG. P-39$1/2$

PAR. P-299(*d*). Modify proposed revision of first section appearing in March, 1942, MECHANICAL ENGINEERING, as follows:

All valves and fittings on all feedwater piping FROM [between] the boiler TO AND INCLUDING [proper and] the required STOP AND CHECK [valve or] valves shall be equal at least to the requirements of the American Standard for a pressure 25 per cent in excess of the maximum allowable working pressure of the boiler EXCEPT AS OTHERWISE STATED.

PAR. P-310(*c*). Revise first sentence to read:

In all cases the valves and fittings FROM THE BOILER TO AND INCLUDING THE REQUIRED STOP VALVES shall be equal at least to the requirements of the American Standards, etc.

TABLES P-6 AND U-3. Modify the proposed revisions appearing in March, 1941, MECHANICAL ENGINEERING as follows:

(1) For the values for Admiralty metal and copper, use those appearing in Table U-3 of the 1940 Edition of the Code;

(2) Insert a column for 300 F and interpolate the values between 250 and 350 F, with the exception that the value for Naval brass at 300 F is to be 10,000;

(3) Change the value for Naval brass at 350 F from "6000" to "6500."

PARS. A-100 to A-123. To be deleted.

MATERIAL SPECIFICATIONS. The following specifications are to be revised to make them identical with the latest A.S.T.M. specifications: S-7, S-11, S-13, S-17, S-18, S-20, S-22, S-23, S-24, S-33, S-34, S-36, S-37, S-38, S-41, S-43, S-45, S-46, S-48, S-50, S-52, S-53, S-54, S-56, S-57, S-58, S-61, S-62. In the note preceding Par. 1 of Specification S-18, the reference to A.S.T.M. Specifications A106-39 to be changed to "A106-41." The following A.S.T.M. specifications will be added to Section II: S-64—A.S.T.M. Spec. A249-41T on Atomic-Hydrogen-Arc-Welded and Electric-Resistance-Welded Alloy-Steel Boiler and Superheater Tubes; S-65—A.S.T.M. Spec. A250-41T on Electric-Resistance-Welded Carbon-Molybdenum Alloy-Steel Boiler and Superheater Tubes; S-66—A.S.T.M. Spec. B13-41 on Copper Boiler Tubes.

RULES FOR WELDING BOILERS OF LOCOMOTIVES. It is proposed to add the following paragraphs to Section III of the Code:

L-101. Shells, fireboxes, domes, or other cylindrical pressure parts and noncylindrical pressure parts, except stays and braces, may be fabricated by means of fusion welding provided the construction is in accordance with the requirements for material and design as required by this Code, and the fusion-welding process used conforms to the following specifications. For the Standard Qualification for Welding Procedure and Welding Operator see Section IX of the Code.

DEFINITIONS

(The definitions to follow will be identical with those given in Par. P-101.)

L-102. (This paragraph will be identical with Par. P-102.)

L-103 *Material.* (*a*) The materials used in the fabrication of any fusion-welded boiler shell, dome, firebox, or other pressure part shall conform to Specifications S-1, S-42, S-43, S-44, S-53, or S-55 of Section II of the Code. Pipe of tubing shall conform to Specifications S-17, S-18, S-32, S-40, or S-49, and steel pipe flanges to Specification S-8. The carbon content of all such material shall not exceed 0.35 per cent.

(*b*) Material for mud rings, door hole or manhole rings, or other nonpressure parts may be of cast or forged steel conforming to Specifications S-11, S-7, S-10, S-56, S-33 grades C-11 or C-4.

L-104 *Preparation For Welding.* (*a*) The plates may be cut to size and shape by machining or shearing, or by flame cutting. If shaped by flame cutting, the edges must be uniform and smooth and must be free of all slag and scale accumulations before welding. The discoloration which may remain on the flame cut surface is not considered to be detrimental oxidation.

(*b*) If the thickness of a flange to be attached to a cylindrical shell by a butt joint exceeds the shell thickness by more than 25 per cent (maximum $1/4$ in.), the flange thickness shall be reduced at the abutting edges either on the inside or outside, or both, as shown in Figs. L-12, L-15, and L-16.

(*c*, *d*, and *e* will be identical with Pars. P-104*c*, *d*, and *e*.)

L-105 *Joints.* (*a*) Longitudinal, circumferential, and other joints uniting the plates of the boiler shell, dome, drum, or other pressure parts, except as provided for in Pars. L-113 and L-115, shall be of the double-welded butt-joint type and shall be reinforced at the center of the weld on each side of the plate by at least $1/16$ in. up to and including $5/8$ in. plate, and up to $1/8$ in. for heavier plates. (The balance will be identical with Par. P-105, beginning with the second sentence.)

L-106. (This paragraph will be identical with Par. P-106.)

L-107. *Stress Relieving.* All pressure parts of locomotive boilers fusion welded under the provisions of Pars. L-101 to L-106, inclusive, shall be stress-relieved. (The balance will be identical with Par. P-108, beginning with the second sentence.)

L-108 *Hydrostatic and Hammer Tests.* (*a*) The completed boiler and/or other pressure parts shall be subject to a hydrostatic test of $1\text{-}1/2$ times the maximum allowable working pressure. The pressure shall be under proper control so that in no case shall the required test pressure be exceeded by more than 6 per cent.

(*b*) While subject to this pressure all butt-welded joints which are unsupported by other

means, and all welded joints, where such a test is feasible, shall be given a thorough hammer or impact test. This test shall consist of striking the plate at 6-in. intervals on both sides of the welded joint and for the full length of all welded joints. The weight of the hammer in pounds shall approximately equal the thickness of the shell in sixteenths of an inch, but not to exceed 10 lb, and the plate shall be struck with a sharp swinging blow. The edges of the hammer shall be rounded so as to prevent the defacing of the plates.

(*c*) The maximum allowable working pressure shall be that determined by the formula in Par. L-21 based on the actual thickness and dimensions of the shell. The hydrostatic test shall be made with water of a temperature not less than the temperature of the surrounding atmosphere and in no case less than 70 F.

(*d*) Following the hammer test, the pressure shall be raised to not less than twice the working pressure for a sufficient time to enable a complete inspection to be made of all joints and connections.

(*e* and *f* will be identical with Par. P-109*d*, *e*, and *f*.)

L-109. (This paragraph will be identical with Par. P-110.)

L-110. (This paragraph will be identical with Par. P-111.)

L-111. Superheater tubes complying with any of the specifications of Par. L-103 and not exceeding $2^1/_2$ in. in diameter may be fusion welded to tubular welds similar to Fig. L-14(c) and shall be stress relieved. Radiographic and hammer tests of the welds may be omitted.

A hydrostatic test shall be made at twice the maximum working pressure.

L-112. (This paragraph will be identical with Par. P-115, except that item 6 is to be omitted.)

L-113. (Section (*a*) will be identical with Par. P-186(*b*) except that the words "and no qualification of welding operator is required" in the last sentence is to be deleted.)

(*b*) Joints between the doorhole flanges of furnace and exterior sheets may be butt- or lap-welded by the fusion process, provided these sheets are stayed or otherwise supported around the doorhole opening and provided the distance from the flange to the surrounding stays or other supports does not exceed the permissible staybolt pitch as specified in Par. L-31. If the joints are lap-welded the exterior sheet flange should be on the door opening side and the firebox flange should be on the water side of the door-hole joint. Fusion-welded joints may be used in lieu of riveted joints in the fireboxes of internally fired boilers provided the welds are between two rows of staybolts, or in the case of flat surfaces the weld is not less than one half of a staybolt pitch from the corner.

Any crevices between the mud ring and the sheets of a locomotive boiler may be made tight by seal welding when the mud ring is secured by riveting. The abutting ends of mud rings may be welded.

(Section *c* is to be identical with the second section of Par. P-200, omitting the words "under the provisions of Par. P-112.")

L-114. *Domes.* Domes may be of seamless drawn construction, with or without integral heads, provided the material conforms to the Code requirements for shell material, or may be rolled, welded, and flanged. The longitudinal joints of a dome may be butt-welded and the dome flange may be attached to the shell by a double-welded butt joint if the welding complies with Pars. L-101 to L-107, inclusive.

The dome liner may be attached by full fillet welds to the boiler shell and the body of the dome as shown in Fig. L-15(E), if a flanged type of liner is applied, provided the welding complies with the requirements of Pars. L-101 to L-107, inclusive. Radiographic examination of the fillet welds may be omitted.

When a dome is located on the barrel of a boiler, its diameter shall not exceed six-tenths of the diameter of the shell or barrel. If located on a tapered course, the allowable diameter shall be based on the diameter of the tapered course that intersects the axis or center line of the dome.

Flanges of domes shall be formed with a corner radius, measured on the inside, of at least twice the thickness of the plate for plates 1 in. in thickness or less, and at least 3 times the thickness of the plate for plates over 1 in. in thickness.

Domes or manhole frames attached to shells or heads of boilers shall be reinforced in accordance with the provisions of Par. L-115.

L-115. *Reinforcement of Openings.* (*a*) All openings over $3^1/_4$ in. in diameter and/or exceeding $4^1/_2$ times the thickness of the plate must be suitably reinforced in accordance with the provisions of this paragraph.

(*b*) An opening in the shell of a boiler with a diameter greater than the maximum unreinforced opening permitted by (*a*) shall be provided with reinforcement. Openings of the reinforced type shall consist of one or more reinforcing rings or flanges welded to the shell and/or a tube or pipe extension or fitting welded to the shell and/or welded to or integral with the reinforcing flange.

(Section *c* will be identical with Par. P-268*g*.)

(Section *d* will be identical with Par. P-268*b*.)

(*e*) Material for fusion-welded connections shall be in accordance with Par. L-103. All welding for fusion-welded connections shall be equivalent to that required under the rules in Pars. L-101 to L-110, inclusive. Where a nozzle is attached to a boiler by a flange or saddle inserted in and butt-welded to the shell at the edge of the flange as shown in Fig. L-16, the weld so made shall be radiographed. Radiographic examination of other types of nozzle may be omitted. Fig. L-14 illustrates some types of fusion-welded connections which are acceptable.

NOTES ON NEW FIGURES REFERRED TO IN THESE PROPOSED NEW RULES

("P" designations refer to Power Boiler Code)

Fig. L-8 is to be identical with Fig. P-1

Fig. L-9 is to be identical with Fig. P-2 of the Power Boiler Code

Fig. L-10 is to be identical with Fig. P-3 of the Power Boiler Code.

Fig. L-11 is to be identical with Fig. P-4 of the Power Boiler Code

Fig. L-12 is to be identical with Fig. P-5 of the Power Boiler Code

Fig. L-13 is to be identical with Fig. P-6 of the Power Boiler Code

Fig. L-14 is to be identical with Fig. P-36 of the Power Boiler Code

Fig. L-15 (*a*), (*b*), (*c*), (*d*), is to be identical with Fig. P-37 (*a*), (*c*), (*d*), (*f*), respectively. Illustration (*e*) of Fig. L-15 will be as shown below

Fig. L-16 is to be identical with Fig. P-38 of the Power Boiler Code.

FIG. L-15 (*e*)

PAR. L-82. Revise to read:

L-82 (a) *Inspection.* Each boiler, superheater, or other pressure part shall be inspected during construction and after completion. At least two inspections shall be made of riveted construction (one before reaming the rivet holes and one at the hydrostatic test) and, at the option of the inspector, at such other stages of the work as he may designate. For inspection of welded construction, see Pars. L-102 to L-115 (proposed), inclusive. The inspector certifying to the tubes shall determine if the tubes comply with these rules.

(*b*) *Inspectors.* The inspection required by this section of the Code shall be made by a state inspector, a municipal inspector, or an inspector employed regularly by an insurance company. These inspectors shall have been qualified by a written examination under the rules of any state which has adopted the Code.

(*c*) *Code Symbols.* Each boiler to which the Code symbol is to be applied shall be fabricated by a manufacturer who is in possession of a Code symbol stamp (see Fig. L-6).

Permission to use the symbol designated will be granted by The American Society of Mechanical Engineers to any manufacturer complying with the provisions of this Code who will agree, upon forms issued by the Society, that the boiler to which the symbol is applied will be constructed in full accordance with Code requirements and that he will not misuse or allow others to use the stamp by which the symbol is applied. All steel stamps for applying the Code symbols shall be purchased by such manufacturers from the Society.

(*d*) *Data Reports.* Manufacturer's data report form L-2 shall be used to record all of the items comprising a complete locomotive boiler unit requiring Code inspection. Copies of this report shall be furnished to the inspection agency and the state or municipal authority.

(*e*) The inspector shall sign the certificate of boiler shop inspection certifying that the boiler conforms to the requirements of the A.S.M.E. Code.

(*f*) *Stamping.* The manufacturer shall stamp the boiler, which has been constructed in compliance with the Code, in the presence of the inspector, after the hydrostatic test in the shop of the manufacturer.

(*g*) The stamping shall consist of the A.S.M.E. Code symbol shown in Fig. L-6 which shall be placed in the location given in Par.

L-83. In addition to the symbol, the following items shall also be stamped with letters and figures at least $^5/_{16}$ in. high, as shown in Fig. L-7:

(1) Manufacturer's serial number
(2) Name of manufacturer
(3) Maximum allowable working pressure when built
(4) Year built.

(*b*) No accessory or any part of a boiler may be marked "A.S.M.E." or "A.S.M.E. Std." unless so specified in the Code.

HEATING BOILER CODE. Add the following to the preamble:

For the purposes of these rules, a domestic water heater is one which supplies hot water and is connected to a tank with a capacity of 120 gal or less. A range boiler is a ferrous or nonferrous tank with a capacity of not over 120 gal for the storage of water at temperatures not over 212 F and pressures not over the working pressure marked on the tank. The hot water may be supplied from an external source or the range boiler may have a self-contained gas or oil burner or electric-heating unit.

PARS. H-61 and H-114. Add the following:

(Transparent material other than glass may be used for the water gage provided that material has proved suitable for the pressure, temperature, and corrosive conditions met with in service.)

PAR. U-2. Add the following:

The dial of a pressure gage shall be graduated to approximately double the pressure at which the relieving device is set to function but in no case less than $1^1/_2$ times that pressure.

PAR. U-13(*b*). Revise the last sentence to read:

All such steel shall conform to Specification S-1 EXCEPT FOR THE TENSILE LIMITS.

PAR. U-76*e* (4). Revise to read:

(4) Nozzles or other welded attachments for which stress relief is required may be locally stress-relieved by heating a circumferential band AROUND THE ENTIRE VESSEL with the connection at the middle of the band, the band WIDTH to be, etc.

PARS. U-97 to U-109. To be deleted.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Production Engineering

PRODUCTION ENGINEERING. By Earle Buckingham. John Wiley & Sons, New York, N. Y., 1942. Cloth, 6 × 9 in., 268 pp., $2.50.

REVIEWED BY J. M. JURAN[1]

IN his preface, Professor Buckingham indicates that his purpose is to prepare an "assembly drawing" of the subject of production engineering and thus to portray to those who have studied the disjointed elemental subjects of production engineering how these elements go together and what holds them together. It must be said that the author has completed his task quite as announced, and with the skill of the artist assembling a mosaic.

Professor Buckingham writes with a forcefulness and confidence well warranted by his precision of argument. He has scorned the use of pictures, figures, or charts, and this to the bitter end, for the book contains not a single one. Yet there can be no criticism for lack of lucidity. If anywhere in the book there is an area which permits of more than one interpretation, it has escaped this reviewer. All this is notwithstanding the presence of some degree of ghost writing, for the good Professor has assigned, *a priori*, all credit for elegance in diction to his wife.

In the preparation of so broad an assembly there is always before the author the temptation to emphasize that part of the field in which his experience has been the most intense. There is no evidence that Professor Buckingham has succumbed to this temptation, for the treatment is well balanced. More than this, the numerous and pertinent case experiences related are so uniformly distributed throughout the book as to dispel any notion that this is an academic treatise. The breadth of experience reflected in these examples pervades the remainder of the book thoroughly.

It is particularly gratifying to note the way in which the presence of the human factor as an important variable is realistically emphasized. Professor Buckingham enters this normally polished area with heavy boots. Note the introduction to a section on "Personnel:"

"Regardless of organization charts, contracts, agreements, or other formal written statements of relationships, obligations, and responsibilities, any organization is nothing more or less than a group of individual persons who spend a large part of their waking hours working in the same place in the attempt to accomplish some common task. Personal feelings often affect their actions more than reason or logic. This holds true for all, from the top to the bottom. Common sense is the rarest sense that is used. 'Common sense is the gift of the gods to the chosen few—I have only a technical education!'

"Here we have a cross section of our social and political society. Every virtue and vice of society in general has its counterpart here. Greed and altruism, politics and graft, co-operation and self-seeking, fraternity and snobbery, knowledge and bluffing, honesty and dishonesty—all make part of the problem. Many problems which appear on the surface to be technical in character turn out to be problems in human relationships." (P. 101)

The author dwells but little on detailed technical problems—he undertakes to do this only "when the existing texts appear to be inadequate or nonexistent." He tarries on his swift tour of the field for several such problems: Dimensioning with tolerances, the maximum and minimum metal size concept of gaging, and the design of tools and gages. These elaborations are most welcome. In fact, one wishes the author might also have given more time to some of the currently pressing problems of time and motion study and the related problems of piece rates.

Another zone of elaboration is in the field of factory costs. Here Professor Buckingham distinguishes between the

[1] Acting Assistant Administrator, Office of Lend Lease Administration, Washington, D. C. Member of A.S.M.E. Management Executive Committee.

cost problems of the accountant and those of the engineer, to the point of suggesting that a dual cost system may be in order. This raises a number of important questions, and it must be said that only few of them are covered in any gratifying detail.

This book must be characterized as an outstanding addition to the material available for the advanced student of Production Engineering. More than this, it can be a refreshing fountain to the practicing engineer who may have advanced on but one front of the entire field. It derives this characteristic from its exemplary clarity of expression quite as fully as from its technical excellence.

Plant Production Control

PLANT PRODUCTION CONTROL. By C. A. Koepke. John Wiley & Sons, Inc., New York, N. Y., 1941. Cloth, 6 × 9 in., 509 pp., illus., $4.

REVIEWED BY KENNETH H. CONDIT[2]

ON THE jacket of Professor Koepke's book the statement is made that each of the functions involved in plant production control is treated separately, "yet co-ordinated with the others to show how control of production is obtained." An examination of the various chapters indicates that much valuable material on each of the functions has been included but the impression remains that the co-ordination might have been better done. Each chapter is a complete unit in itself but it is difficult to see why some of them are introduced in the order adopted by Professor Koepke.

Another criticism that seemed fair to the reviewer is the inclusion of some fifty pages of economic history which is essentially introductory in character. Some very hard things have been said about the propensity of college-faculty textbook writers and lecturers to introduce every subject by giving all the back history which may or may not be vital to an understanding of the subject. In this case it would seem that the general presentation of "Plant Production Control" would be hurt not at all by eliminating this historical matter.

The text is well illustrated and unusually well documented, and the inclusion of questions with each chapter is certainly an asset where the book is to be used as a college textbook. On the other hand, the independent nature of each chapter would seem to make the book more suitable as a reference work for practicing production men than for students.

[2] Dean of Engineering, Princeton University, Princeton, N. J. Past Vice-President, A.S.M.E.

Marks' Handbook

MARKS' MECHANICAL ENGINEERS' HANDBOOK, fourth edition. McGraw-Hill Book Company, Inc., New York, N. Y., 1941. Fabrikoid, 4⅝ × 7 in., 2274 pp., illus., thumb-indexed, $7.

REVIEWED BY ARTHUR M. GREENE, JR.[3]

THE fourth edition of the "Mechanical Engineers' Handbook," edited by Lionel S. Marks, follows the same excellent form and content of the editions of 1916, 1924, and 1930. The list of contributors to the same sixteen sections is larger than before and includes outstanding engineers conversant with special fields of engineering.

Some sections of the book have had the matter in the earlier edition abridged to have space for new matters developed in the last decade. Some of the deleted matter has been deemed unimportant by the specialists because of their familiarity with these subjects and they have appeared to forget the user of the handbook who needs this information which has been omitted. This is the only adverse criticism by one who has found the earlier editions of greatest value during a use covering a quarter of a century.

As in the previous editions the new one is in a single volume and contains data for the use of the mechanical engineer when he practices in that broad field that demands data and methods from other specialized fields of civil, electrical, and metallurgical engineering. The reviewer has found most of his questions answered as he has thoroughly examined each division of the book. That he could answer these questions from a single volume has been of particular value to him when desk space is limited.

The new tables of symbols and abbreviations at the opening of the book, prepared in accordance with the rules of the American Standards Association, aids the engineer in his writing and study. This is followed by those most complete sections (1 and 2) of the earlier edition covering the mathematical tables and the subjects of weights and measures, arithmetic, algebra, geometry, trigonometry, calculus, graphical representation of functions, and closing with vector analysis. These two sections have been of great use to the reviewer from the time of the first edition.

The titles of the sixteen sections have not been changed but new divisions have been made from the collection of matter at different parts of the former edition, in eliminated divisions by rearrangement, and by matters not covered before. The new arrangement of matter has improved the book. The new divisions have the titles: Theory of models, mixture of gases and vapors, mechanical properties of materials, packings, aircraft propellers, wind pressure on structures, and sound and noise.

Such subjects as critical speed of multiple loaded shafts, creep of material under strain, radiation from gases, fatigue failures, surface fatigue, magnaflux testing, material testing, extensometers, reinforced-concrete design in accordance with the Specifications of 1940, new alloys, rubber-belt data, V-belt and pivoted motor drives, American Standards for pipe and fittings, as well as anti-knock characteristics of fuels, are found in the text, and in most cases the developments of the last decade have been included. The full discussion of combined stresses has been omitted from each of the sections dealing with this subject and there have been omissions in data and methods in the sections dealing with steam turbines, steam boilers, refrigerating machines, and cooling towers.

This new edition is of particular value because of the new matter added and for the form and arrangement which was developed in the first edition of 1916. The printing of the book is clear and the manufacture of the book is excellent. This new edition will retain its high position among engineering handbooks.

[3] Dean Emeritus, School of Engineering, Princeton University, Princeton, N. J. Past Vice-President and Hon. Mem. A.S.M.E.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

Books Received in Library

A.S.T.M. STANDARDS SUPPLEMENT, including TENTATIVE STANDARDS. Part 1, Metals, 597 pp.; Part 2, Nonmetallic Materials—Constructional, 427 pp.; Part 3, Nonmetallic Materials—General. 641 pp.; American Society for Testing Materials, Philadelphia, Pa., 1941. Cloth, 6 × 9½ in., illus., diagrams, charts, tables, $3 for any one part, $5 for any two parts, $7 for all three parts. To keep up to date its triennially published Book of Standards, the American Society for Testing Materials publishes, in the two intervening years, supplements to each of the three volumes of that set. This 1941 supplement gives, in their latest approved form, the 370 specifications, tests, and definitions either issued for the first time in 1941 or revised.

ARMS AND THE AFTERMATH. By P. Stryker. Houghton Mifflin Co., Boston, 1942. Cloth, 5½ × 8½ in., 157 pp., tables, $1.75. The meaning of industrial mobilization is explained, together with the importance of effective mass-production methods, and the results of the change-over and tremendous financing problems for rearmament are indicated. The purpose is to give the reader a behind-the-scenes view of the causes, functioning, and effects of this mobilization of industry for the war effort.

ART OF CAMOUFLAGE. By C. H. R. Chesney. Robert Hale, Ltd., London, England, 1941. Cloth, 5 × 8 in., 253 pp., illus., maps, 8s 6d. Camouflage, "the art of concealing the fact that you are concealing," is thoroughly covered in this book. The first section discusses camouflage as practiced by creatures in their natural environment and presents general considerations upon civil camouflage. The second section discusses the development of military camouflage in the war of 1914–1918 and future developments for both military and civil use. Strategic camouflage in military movements is demonstrated in the last section, with examples from campaigns. In this section and in an epilogue the author stresses also the political camouflage which will be used and has been so amply demonstrated just recently.

BASIC REFERENCE FORMS, a Guide to Established Practice in Bibliography, Quotations, Footnotes, and Thesis Format. By G. L. Joughin. F. S. Crofts & Co., New York, 1941. Cloth, 5½ × 8½ in., 94 pp., tables, $0.80. The purpose of this book is to present to the writer of undergraduate term papers and to the beginning research student a set of basic reference forms for use in documentation. General principles are given for forms of references, methods of assembling them, quotations, footnotes, and the general format of a thesis. Sample reference forms from various special fields are included.

DIESEL ENGINEERING HANDBOOK, Vol. 2. Edited by L. H. Morrison. Diesel Publications, New York, 1941. Cloth, 6 × 9½ in., 574 pp., illus., diagrams, charts, tables, $5. This volume is intended to supplement both the 1935 and 1939–1940 editions. The material contained is either entirely new or an amplification of topics considered in the previous editions. Engine efficiencies, specifications, special installations, and various types of auxiliary equipment not previously covered are discussed exhaustively with many illustrations.

DONE IN OIL. By D. D. Leven. Carldon Publishers, New York, 1941. Leather, 6 × 9½ in., 1084 pp., illus., diagrams, charts, maps, tables, $10. The first section of this comprehensive volume covers general petroleum economics, oil reserves and conservation, the international situation, and the importance of oil in war. The succeeding five sections deal respectively with finding and producing oil; transportation and refining; financing the oil industry; oil royalty, business, and investments; and the regulating of securities and markets. Sample leases and deeds, a large glossary of terms, and a list of sources of further information are appended.

ELEMENTARY PLANE SURVEYING, Text and Manual. By R. E. Davis. Second edition. McGraw-Hill Book Co., New York and London, 1941. Cloth, 4½ × 7½ in., 464 pp., illus., diagrams, charts, tables, $3. This text is prepared for students of architecture, forestry, electrical and mechanical engineering, and others who wish a short course in the subject. It combines a classroom text and a manual of field and office exercises and is designed for a one-semester course. The new edition has been entirely rewritten, and considerable new material has been added.

ELLIPTIC CYLINDER AND SPHEROIDAL WAVE FUNCTIONS, including Tables of Separation Constants and Coefficients. By J. A. Stratton, P. M. Morse, L. J. Chu, and R. A. Hutner. A publication of the Technology Press, Massachusetts Institute of Technology. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1941. Paper, 8½ × 11 in., 127 pp., diagrams, charts, tables, $1. This publication defines certain standard forms of the solution of the wave equation, and displays a collection of formulas giving the important mathematical properties of certain elliptic and spheroidal functions. There is also a set of tables from which values of the solutions can be obtained for the more interesting ranges of the variables. The intention is to increase the practical use of these mathematical tools.

EXPERIMENTAL PHYSICAL CHEMISTRY. By W. G. Palmer. The Macmillan Co., New York; Cambridge University Press, London, England, 1941. Cloth, 5½ × 8½ in., 321 pp., diagrams, charts, tables, $2.75. The experiments presented have been chosen among those used in the University Chemical Laboratory at Cambridge, choice having been of those which can be carried out in customary laboratory periods with ordinary equipment. Detailed directions are given, and the principles involved are set forth in considerable fullness. There are completely worked examples of most experiments.

FATIGUE OF WORKERS, Its Relation to Industrial Production. By Committee on Work in Industry of the National Research Council. Reinhold Publishing Corp., New York, 1941. Cloth, 6 × 9½ in., 165 pp., $2.50. This volume is the complete report of the findings of a committee which made a detailed study of all kinds of variations in working conditions; both physical and psychological considerations were investigated with respect to their effect upon the efficiency of workers. The results of this painstaking study should be of value to employers of all classes.

FINANCIAL STATEMENT ANALYSIS, Principles and Technique. By J. N. Myer. Prentice-Hall, New York, 1941. Cloth, 6 × 9½ in., 257 pp., charts, tables, $3.75. Financial-statement analysis is considered as a branch of accountancy, and an understanding of such statements and the accounting processes by which they are produced is assumed. The object of the book is to develop sound principles for a technique of analysis and interpretation of the financial statements of business enterprises, and the application of these principles is illustrated in a practical manner.

Great Britain. Dept. of Scientific and Industrial Research. INDEX TO THE LITERATURE OF FOOD INVESTIGATION, Vol. 13, No. 1, compiled by A. E. Glennie and others. His Majesty's Stationery Office, London, England, 1941. Paper, 6 × 9½ in., 78 pp., 4s 6d. (Obtainable from British Library of Information, 30 Rockefeller Plaza, New York, $1.35.) This valuable publication provides abstracts of the literature of the food industry as it appears in periodicals. All phases of the subject are covered, including such problems of engineering as temperature and humidity control, transportation methods, insulation, refrigeration, and air conditioning. An author index is provided.

HANDBOOK OF CHEMISTRY AND PHYSICS, a Ready-Reference Book of Chemical and Physical Data. Twenty-fifth edition, edited by C. D. Hodgman and H. N. Holmes. Chemical Rubber Publishing Co., Cleveland, Ohio, 1941. Fabrikoid, 5 × 7½ in., 2503 pp., diagrams, charts, tables, $3.50. The popularity of this well-known reference work is indicated by the appearance of twenty-five editions in twenty-eight years. The present issue retains the original purpose—to provide accurate data constantly wanted by physicists and chemists in convenient form for quick reference. The present edition has been revised throughout and new matter added where called for.

HYDRAULICS. By H. W. King, C. O. Wisler, and J. G. Woodburn. Fourth edition. John Wiley & Sons, Inc., New York, N. Y., Chapman & Hall, London, England, 1941. Cloth, 6 × 9 in., 303 pp., diagrams, charts, tables, $2.75. The fundamental principles of hydraulics are presented, including applications in engineering practice, to provide a text for beginning courses and also to serve as a reference book. The material has been revised in accordance with recent trends of research and practice, expanded treatment being given to the subjects of viscosity, manometers, the energy theorem, laminar flow, compound pipes, and nonuniform flow in open channels.

HYDRAULICS OF STEADY FLOW IN OPEN CHANNELS. By S. M. Woodward and C. J. Posey. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1941. Cloth, 6 × 9½ in., 151 pp., diagrams, charts, tables, $2.75. The theory of the steady flow of water in open channels is presented in concise form, suitable for use in senior and graduate courses and for home study. Backwater curves and flow profile analysis under varying conditions receive particular treatment. Certain related topics, such as the moving hydraulic jump and slowly varied flow, are also considered.

IRON HORSES, American Locomotives 1829–1900. By E. P. Alexander. W. W. Norton & Co., New York, 1941. Cloth, 8½ × 11½ in., 239 pp., illus., diagrams, woodcuts, $5. This book is a pictorial story of the development of the American locomotive from the first engine to run on rails, in 1829, down to the turn of the century. Following a brief historical résumé of the early years comes a chronological series of prints and lithographs, with case histories, depicting typical locomotives of the years covered by the book. An alphabetical directory of locomotive builders of the United States, past and present, is appended.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

A.S.M.E. 1942 Semi-Annual Meeting to Discuss War-Production Problems

Preliminary Plans Announced Covering Sessions at Statler Hotel, Cleveland, Ohio, June 8–10

AS THE conversion of industry into war production becomes more complete and the interests of the entire nation are directed almost exclusively to the winning of the war, it is natural that the program of the Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held in Cleveland, Ohio, June 8–10, 1942, with headquarters at the Hotel Statler, should be devoted principally to subjects related to the engineer's part in an all-out effort to back up the armed forces in their fight for victory.

Visit to Nela Park Planned

But if the war changes the character of A.S.M.E. technical-paper programs, it also affects other phases of Society meetings. Local plant visits, which have always been a particularly valuable feature of former gatherings, are, in times of war, almost impossible to arrange, as the committee in charge of events at Cleveland has discovered.

Plant visits present a particular obstacle in the rigid restrictions of the War Department. A great deal of war production is going forward in the Cleveland area. Practically all plants of special interest to engineers are now under contract. In order to comply with such restrictions, it will be necessary for visitors to come prepared to furnish complete identification such as birth certificates and citizenship credentials from their respective companies.

One of the high lights in the Committee's plans is an invitation from the General Electric Company to visit Nela Park. There, at the General Electric Institute, a fascinating display of lighting in all its phases is to be demonstrated in complete form. A most interesting program is promised. If weather permits, the guests will be invited also to enjoy the open-air facilities of the near-by camp with complete recreation room and picnic facilities.

The war also affects the availability of papers prepared far enough in advance of presentation for preprinting. Not only is time for preparation a factor which authors find difficult to contend with, but the desire to present the very latest developments contributes to delay. Moreover, there are restrictions on what may be published in wartime that are more severe than those which are laid on what may be said in informal discussion provided no printed record is made. This makes attendance at meetings more than ever necessary to the engineer who is eager to exchange ideas with others engaged in his line of work and to pick up what information he can on most recent practice. These special reasons that the times impose must be considered by mechanical engineers in coming to a decision to attend technical meetings. To many it will be clear that more than ever is attendance necessary; and in this opinion they will be upheld by the agencies in Washington which are constantly urging that more meetings on subjects relating to war production be planned and sponsored by the A.S.M.E.

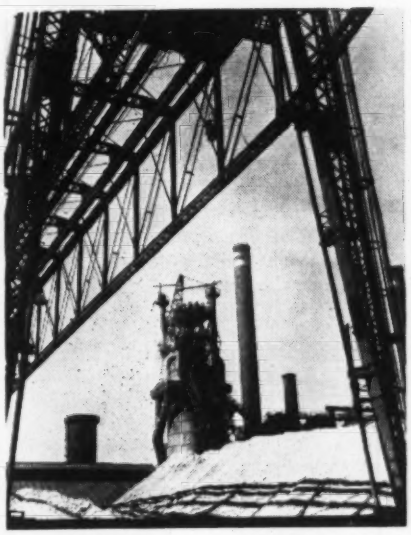
A VIEW FROM THE LAKE FRONT GARDEN, CLEVELAND

(Corner of Municipal Stadium on left and Terminal Tower in background.)

TERMINAL TOWER-DEVELOPMENT FROM WEST, CLEVELAND

Innovation to Be Tried at Aviation Production Session

A new experiment is being tried at Cleveland by the A.S.M.E. Aviation Division in devoting one session to the discussion of problems of production of airplane parts and accessories. The purpose of this session is to enable the engineering staffs of factories starting the manufacture of airplane parts and airplane accessories to exchange notes on their experiences in order that their technique and speed



BLAST FURANCE AT CLEVELAND[1]

of manufacture may be improved. There will be no prepared papers, and the meeting will be of a confidential nature. Notes will be prepared on the discussions which after being edited by each discusser will be distributed to the members who were present.

It is expected that a free discussion of difficulties, failures, and successes in the manufacture of airplane parts and accessories will be a distinct advantage to the war-production program as relates to aviation.

If this session proves as successful as it is hoped for, other such meetings will be held in aviation manufacturing centers.

S.A.E. to Co-Operate

At a specially organized session devoted to the speeding up of war production, The Society of Automotive Engineers will co-operate with The American Society of Mechanical Engineers in a forum of particular interest to production men in small plants. What can be accomplished by making the best use of every machine tool, regardless of whether or not under peacetime conditions it would be considered ideally suited to the job, will be the theme of the session. A representative of the War Production Board will lead the discussion of this all-out machine-use problem. The subject is an important one and great benefit should be derived from the examples of ingenuity and resourcefulness that the forum should lay bare. Engineers engaged in production problems are particularly urged to be present to exchange ideas.

Technical Program Features War Production

Although complete details of the technical program of papers cannot be announced at this time, arrangements are sufficiently advanced to give an outline of the principal contributions of many of the Society's professional divisions. Technical sessions will begin on Monday morning and continue through Wednesday.

According to present plans the Aviation Division will sponsor two sessions. At the first session E. W. P. Smith, of the Lincoln Electric Co., Cleveland, Ohio, will present a paper on aircraft welding. This will be followed by two other papers, one on the strength characteristics of plastic-bonded plywood, by George B. Parsons, chief of the stress department, Duramold Aircraft Corp., and the other on cold-rolled stainless steel in aircraft, by S. M. Norwood, of the Electro Metallurgical Co.

At the second aviation session there will be a conference on aviation war production at which there will be a round-table discussion of production problems. No formal papers have been arranged, but leaders in the industry will be on hand to take part in the discussion.

Papers on Education

The A.S.M.E. Committee on Education and Training for the Industries will sponsor three sessions, one on education and training for industry before and after the war, and the other on co-operative and adult education. At the first session the speakers will be James D. Cunningham, president, Republic Flow Meters Co., Chicago, Ill.; Clyde A. McKeeman, of the Case School of Applied Science and director of Defense Training in the Cleveland area; and C. E. MacQuigg, dean of engineering, The Ohio State University.

The speakers at the Session on Co-operative Education will be Cecil V. Thomas, president, Fenn College, Cleveland, Ohio; Mark Ellingson, president, Rochester Atheneum and Mechanics Institute; and Fred E. Ayer, dean of The University of Akron.

Fuels Division to Hold Three Sessions

Three sessions have been planned by the A.S.M.E. Fuels Division. At the first of these sessions R. B. Engdahl, of the Battelle Memorial Institute, Columbus, Ohio, will present a paper on pulverized fuel for forge furnaces, and Lee Wilson, of the Lee Wilson Engineering Co., Cleveland, Ohio, one on radiant-tube furnaces.

Spreader Stokers on the Great Lakes will be the subject of a paper at another of the Fuels Division sessions. Otto deLorenzi, Combustion Engineering Co., New York, N. Y., will present this paper. The second subject of this session will be the use of overfire air in stoker-fired units and the discussion will be led by H. C. Carroll, of the Commercial Testing and Engineering Co., Chicago, Ill.

Plans for the A.S.M.E. Heat Transfer Division include a round-table discussion on shell-and-tube heat exchangers.

A round-table discussion on the subject, training war workers, will be the contribution of the A.S.M.E. Management Division. O. C. Heffner, production manager, Hoover Co., Canton, Ohio, and Kenneth Anderson, executive assistant, National Defense Committee, N.E.M.A., will take part in the discussion.

In a session devoted to materials handling, the A.S.M.E. Materials Handling Division will sponsor a discussion of standardized methods of skid and pallet shipments of commodities.

Although the A.S.M.E. Metals Engineering Division plans to sponsor a session, the program of speakers has not been completed.

Power Division Program

Two sessions will be sponsored by the A.S.M.E. Power Division, the first jointly with the A.S.M.E. Special Research Committee on Critical-Pressure Steam Boilers. Papers to be presented at this session are on the corrosion of stressed alloy-steel specimens in contact with high-temperature steam, by H. L. Solberg of Purdue University, Lafayette, Ind.; the second on an improved technique for the rolling-in of small tubes used in heat exchangers, except boilers, by E. T. Cope and F. F. Fisher, The Detroit Edison Co., Detroit, Mich.; and the third on heat transfer and fluid resistance in regenerative air heaters, by Hilmer Karlson and Sven Holm, Air Preheater Corp., Wellsville, N. Y.

The second session of the Power Division will take the form of a round-table discussion.

War Production Papers by Production Engineering Division

Three sessions have been planned by the A.S.M.E. Production Engineering Division. The first of these sessions will cover the subject of grinding, with papers to be announced. The second session will be devoted to the subject of flame hardening. The process will be explained by representatives of the Linde Products Co. and users of the process will report their experiences with it. At the third session representatives of the Ordnance Department will talk on inspection, and civilian set-ups will be described. It is expected that several types of gaging and inspection devices used by the Ordnance Department will be on display.

Conservation, Substitution, and Reclamation to Be Discussed by Railroad Division

The Honorable Joseph B. Eastman, director, Office of Defense Transportation, Washington, D. C., will deliver the opening remarks at the first of two sessions to be sponsored by the A.S.M.E. Railroad Division. At the first of these A. G. Hoppe, assistant mechanical engi-

CLEVELAND'S TERMINAL TOWER AT NIGHT

[1] All pictures of Cleveland in this issue are published through the courtesy of Cleveland Convention and Visitors Bureau, Inc.

neer, Milwaukee R.R., will speak on conservation and C. B. Bryant, engineer of tests, Southern Railway, on substitution. At the second session the opening remarks will be delivered by Andrew Stevenson, chief, Transportation and Farm Equipment Branch, War Production Board, Washington, D. C. The paper by George A. Goerner, general storekeeper, The Burlington Lines, on reclamation, will be followed by a general discussion of all of the papers of both sessions.

Special Session on Industrial Conservation

A special session on scrap salvage will be conducted by the A.S.M.E. Committee on Industrial Conservation. This committee, of which J. N. Landis, chairman of the A.S.M.E. Standing Committee on Local Sections, is the head, was recently authorized by the Executive Committee of the Council of The American Society of Mechanical Engineers, at the suggestion of the Engineers' Defense Board and with the co-operation of the Conservation section of the War Production Board.

Detailed Program to Be Mailed

In accordance with established custom, a more detailed program of the 1942 A.S.M.E. Semi-Annual Meeting will be mailed to members of the Society sufficiently in advance of the meeting date so that plans can be laid and discussion of papers can be prepared. It is hoped that some of the papers will be available in preprint form in advance of the meeting to facilitate preparation of discussion. However, as already stated, the nature of the times and of the topics discussed by many of the speakers makes it doubtful if any but the papers not specifically relating to war production can be preprinted.

Program for the Women

The Cleveland Committee will follow the customary practice of preparing a special and attractive program for the women who will be present at the meeting. Announcement of this program must await completion of detailed plans. Mrs. T. F. Githens heads the Ladies' Auxiliary in charge of this program.

Seely Heads Cleveland Committee

Arrangements at Cleveland will be in the hands of a Committee of the A.S.M.E. Cleveland section, of which Warner Seely is the general chairman. He will be assisted by Arthur G. McKee, as vice-chairman, and D. W. Williams (hotel), R. E. Erickson (entertainment), Lieut. E. M. Messersmith (plant trips), K. D. Moslander (printing), H. L. Spence (finance), L. E. Jermy (publicity), and Mrs. T. F. Githens (Ladies' Auxiliary).

The A.S.M.E. Cleveland Section is under the chairmanship of J. P. Dearasaugh, with D. K. Wright as vice-chairman. Other members are E. R. McCarthy, secretary, F. A. Barnes, treasurer, M. F. Langa, R. R. Slaymaker, A. G. Trumbull, W. G. Stephan, and McRea Parker. The technical program has been arranged by the committees of the professional divisions participating in the meeting, the Committee on Professional Divisions, George B. Karelitz, chairman, and other Society committees. All meetings of the Society come under the jurisdiction of the A.S.M.E. Committee on Meetings and Program, of which A. L. Kimball is the present chairman.

A.S.M.E. Council to Meet at Cleveland

A meeting of the entire Council of The American Society of Mechanical Engineers will be a feature of the 1942 Semi-Annual Meeting. It will convene on Sunday, June 7. There will also be a regular business meeting of the Society at which any matters concerning the interests of members may be discussed. As usual, the A.S.M.E. Nominating Committee will hold sessions at which members of the Society are invited to speak on behalf of their choices for Society officers to be elected in the fall. The Nominating Committee will make its selections during the meeting and the announcement of these selections will be made as soon as possible. Biographical sketches of the nominees chosen will be published in MECHANICAL ENGINEERING in the July or August issue.

Official Notice

A.S.M.E. Business Meeting

THE semi-annual business meeting of the members of The American Society of Mechanical Engineers will be held Monday afternoon, June 8, 1942, at 2:00 p.m. in the Hotel Statler in Cleveland, Ohio, as a part of the Semi-Annual Meeting of the Society.

(*Signed*) C. E. DAVIES
Secretary

President Parker to Speak at Dinner

During the meeting at Cleveland a dinner will be held on Tuesday evening at which J. W. Parker, president of the Society, will speak. Another speaker of national prominence will also address the dinner. Announcement of the name of this speaker and the subject of his address will be made at a later date.

A.S.M.E. Committee on Industrial Conservation Plans Salvage Meetings

Equipped to Assist in Planning Meetings and Providing Speakers for Local Sections

THE Committee on Industrial Conservation of The American Society of Mechanical Engineers, announced last month, is planning to sponsor a session at the 1942 Semi-Annual Meeting in Cleveland, June 8–10, on the subject of scrap salvage. This session will be conducted along practical lines with the expectation of presenting actual case histories of scrap-salvage schemes that have proved effective. The critical importance of saving every pound of scrap material places on engineers the burden of devising salvage procedures for their individual plants and for making all employees "scrap-conscious."

BIRD'S-EYE VIEW OF CLEVELAND

Scrap-Salvage Meeting in New York on April 28

At the Engineering Societies Building in New York, on April 28, the A.S.M.E. Committee on Industrial Conservation, with the co-operation of the Metropolitan Sections of the engineering societies, is putting on a scrap-salvage meeting. Among the features it is expected that the scrap-salvage program of the Wright Aeronautical Corporation will be described.

J. N. Landis, Chairman

The A.S.M.E. Committee on Industrial Conservation is headed by J. N. Landis, chairman of the Committee on Local Sections. Serving

with Mr. Landis are Harold B. Bergen, Winchester G. Blake, F. D. Carvin, A. R. Mumford, and A. M. Perrin. The Committee is equipped to assist in planning meetings and providing speakers on conservation and salvage. Any A.S.M.E. local section wishing to secure the aid of the committee should communicate with Mr. Landis.

Pittsburgh to Hold All-Day Meeting on May 1

War Technology and Civilian Defense Sessions

THE Pittsburgh Local Section of The American Society of Mechanical Engineers is planning an all-day meeting at the Hotel Roosevelt on May 1 with two general sessions scheduled on war technology and civilian defense. Both sessions will start at 9:30 a.m.

Morning Session

Presiding at the war-technology session will be Thomas E. Purcell, general superintendent of power stations of the Duquesne Light Company. Two addresses are scheduled as follows:

Tailor-Made Molecules From Petroleum Refineries, by W. A. Gruse, Mellon Institute of Industrial Research

Emergency Specifications for War Materials, by Norman L. Mochel, metallurgist, steam division, Westinghouse Electric & Manufacturing Co., Philadelphia, Pa.

Professor W. Trinks of the mechanical-engineering department of the Carnegie Institute of Technology will preside at the civilian defense session when three papers will be presented:

Civilian Defense Against Aerial Bombardment, by C. G. Dunnels, professor of civil engineering, Carnegie Institute of Technology

Natural Gas Restrictions Under the War Production Board, by Flavius B. Jones, general sales manager, Equitable Gas Company

How to Win the War Quickly, by Francis McQuillin, industrial sales manager, West Penn Power Company.

Luncheon Meeting

At the luncheon to be held at 12:45 in the hotel, L. N. Scharnber, chairman of the Pittsburgh Section of the A.S.M.E., will preside and introduce Dr. Phillips Thomas, of the research laboratory of Westinghouse Electric and Manufacturing Company, who will give his demonstration lecture "Adventures in Electricity."

Afternoon Session

In the afternoon, Lieut. Col. D. L. Martin of the Ordnance Department, U. S. Army, will deliver a talk on "The Manufacture of Cannon" and Prof. John E. Younger of the University of Maryland on "Building Tomorrow's Airplanes Today." This will be a continuation of the war-technology session. Presiding will be Lieut. Col. James L. Guion, executive officer, Pittsburgh Ordnance District.

A.S.M.E. Calendar

of Coming Meetings

May 13, 1942
Heat-Transfer Division jointly with A.I.Ch.E.
Boston, Mass.

June 8–11, 1942
Semi-Annual Meeting
Cleveland, Ohio

June 17–19, 1942
Oil and Gas Power Division
Peoria, Ill.

June 19–20, 1942
Applied Mechanics Division
Massachusetts Institute of Technology
Cambridge, Mass.

October 12–14, 1942
Fall Meeting
Rochester, N. Y.

Nov. 30–Dec. 4, 1942
Annual Meeting
New York, N. Y.

(For coming meetings of other organizations see page 28 of the advertising section of this issue)

Actions of A.S.M.E. Executive Committee

Meeting in Society Headquarters on March 18

THE Executive Committee of the Council of The American Society of Mechanical Engineers met in New York on March 18, 1942. President James W. Parker presided, and there were present Clarke Freeman, vice-chairman, G. E. Hulse and C. B. Peck, of the Committee; G. L. Knight (Finance), J. N. Landis (Local Sections), G. B. Karelitz (Professional Divisions), and C. E. Davies, secretary. The following actions were of general interest:

Committee on Industrial Conservation

At the suggestion of the Engineers' Defense Board, a Committee on Industrial Conservation, whose function will be to disseminate information regarding the salvage of industrial materials, was authorized with J. N. Landis as chairman and H. B. Bergen, W. G. Blake, F. D. Carvin, A. R. Mumford, and A. M. Perrin as members.

Inter-American Development Commission

The president was authorized to appoint a committee of three to aid the Inter-American Development Commission, of which Nelson A. Rockefeller is chairman, whenever the commission requested engineering advice in connection with its projects.

"Mechanical Engineering" to Be Sent to Army and Navy Bases

On the recommendation of the Committee on Professional Training of the Engineers' Council for Professional Development the Executive Committee approved in principle the supplying of copies of MECHANICAL ENGINEERING to Army and Navy bases where qualified librarians are located and voted to ask E.C.P.D. to consider in detail a program for maintaining contact with, and upholding the morale of, engineers in the armed forces.

Rotative Project Fund

For the purpose of temporarily financing projects which cannot be covered by regular appropriations the Committee voted to establish a Rotative Project Fund, and to use proceeds from certain gifts, amounting to $4900, as a nucleus of this fund. A Committee, to be appointed by the president, for the purpose of adding to the fund was authorized, and it was decided that no projects would be financed by the fund until at least $25,000 had been secured.

Second Hydraulics Conference

Upon recommendation of the Committee on Professional Divisions with the concurrence of the Hydraulic Division it was voted to accept the invitation of the Iowa Institute of Hydraulic Research, University of Iowa, Iowa City, to act as one of the sponsors of the Second Hydraulics Conference, to be held June 1–4, 1942. The program of the Conference appears on page 408 of this issue.

Power Test Codes

Approval was recorded of adoption as standard practices of the Society of "Revision of Instruments and Apparatus, Part 21 on Leakage Measurements, Chapters 1 and 2;" and "Instruments and Apparatus, Part 2 on Pressure Measurement, Chapter 5 on Liquid Column Gages."

Appointments

The following appointments were reported: Aviation Executive Committee, A. R. Stevenson, Jr.; Special Research Committees: Forging of Steel Shells, W. F. Drysdale; Furnace Performance Factors, A. W. Thorson, W. T. Reid; Sectional Committees: Standardization of Bolt, Nut, and Rivet Proportions, B18, W. R. Halliday, chairman, J. Roy Tanner; Miscellaneous Outside Coal-Handling Equipment, M10, Ralph Sergent; American Standards Association, Mechanical Standards Committee, Alfred Iddles, A. L. Baker, alternate (two years); American Standards Association, Standards Council, W. C. Mueller, C. B. LePage, alternates to Alfred Iddles and A. L. Baker (one year); University of State of New York Conference, Albany, N. Y., March 6, V. M. Palmer, representative.

Meeting With Committee on Publications

After taking a recess for luncheon, the Executive Committee reassembled jointly with members of the Committee on Publications. This marked the third meeting of the Execu-

tive Committee with standing committees of the Society held for the purpose of interchange of ideas and discussion of Society policies. Previous meetings with the Committee on Meetings and Program and Committee on Professional Divisions have been in these pages.

In addition to members of the Executive Committee already noted, the following members of the Committee on Publications were present at the joint meeting: F. L. Bradley, chairman of the Committee on Publications; A. R. Stevenson, Jr., E. J. Kates, and L. N. Rowley, Jr., of the Committee; O. B. Schier, 2nd (advisory member), J. A. Connon and Franklin Fowler, Jr. (Junior advisers); Frederick Lask, advertising manager, and George A. Stetson, editor.

Policies Discussed

An informal discussion of policies and other publication matters of material interest included such subjects as increased paper costs, distribution of Transactions, appropriate subjects for Society papers, and censorship.

Because of general increases in publication costs and in line with trends in other publications, it was jointly voted to increase the nonmember subscription rate of MECHANICAL ENGINEERING from $5 to $6 per year, effective July 1, 1942.

Iowa Institute to Hold Second Hydraulics Conference, June 1–4

A.S.M.E., A.S.C.E., and S.P.E.E. Are Joint Sponsors

ARRANGEMENTS for a Second Hydraulics Conference, to be held at Iowa City June 1–4, are now being completed by the Institute of Hydraulic Research of the University of Iowa. In view of the tremendous role played by the science of fluid motion in the present emergency, the conference will place emphasis upon those phases of hydraulic engineering which involve fundamental principles of mutual importance to other engineering professions and defense agencies of the government. In order that such interchange of knowledge may be of widespread benefit, papers are to be presented not only by outstanding hydraulic engineers, but also by prominent representatives of related scientific fields. The American Society of Mechanical Engineers, the American Society of Civil Engineers, and the Society for the Promotion of Engineering Education are jointly sponsoring the Conference.

The opening session is to be devoted to two general addresses on the application of present-day knowledge of fluid motion to both hydraulic engineering and modern warfare. Aside from an afternoon demonstration of the facilities and research projects of the Institute Laboratory, the six remaining sessions of the four-day conference will be devoted to papers showing the inherent relationship of such pertinent fields as marine engineering, meteorology, conservation, and aviation to various aspects of applied fluid mechanics.

The proposed program, together with the speakers who have already accepted invitations to present papers, is as follows:

Monday, June 1, 9:00 a.m.

Scope and Importance of Fluid Mechanics

The Significance of Fluid Mechanics to the Hydraulic Engineer, Boris A. Bakhmeteff, Columbia University

The Role of Fluid Mechanics in Modern Warfare, Theodore von Kármán, California Institute of Technology

Monday, June 1, 1:30 p.m.

Modern Methods of Research

Latest Developments in Hydraulic Laboratory Technique, Joseph B. Tiffany, U. S. Waterways Experiment Station

Principles of Towing-Tank Research, L. A. Baier, University of Michigan

General Aspects of Wind-Tunnel Investigation, A. M. Kuethe, University of Michigan

Measurement of Sediment Transportation, E. W. Lane, University of Iowa

Tuesday, June 2, 9:00 a.m.

Mechanics of Fluid Resistance

Hydraulic Aspects of Form Drag, Max M. Munk, Catholic University

Evaluation of Boundary Roughness, Hunter Rouse, University of Iowa

Resistance of Nonhomogeneous Fluids

Fluid Flow Through Porous Media, Morris Muskat, Gulf Research and Development Company

Tuesday, June 2, 1:30 p.m.

Inspection of Hydraulics Laboratory

All equipment in the Institute Laboratory will be in operation, and current research projects will be demonstrated by members of the staff

Wednesday, June 3, 9:00 a.m.

Cavitation Phenomena

Cavitation Problems and Their Effect Upon the Design of Hydraulic Turbines, J. M. Mousson, Rustless Iron and Steel Corporation

cavitation Problems in Pumps, George F. Wislicenus, Worthington Pump and Machinery Corp.

Studies of Cavitation in Hydraulic Structures, Harold A. Thomas, Carnegie Institute of Technology, and William J. Hopkins, U. S. Engineer Corps

Wednesday, June 3, 1:30 p.m.

Problems of Wave Motion

Beach Wave Investigations, Martin A. Mason, Beach Erosion Board

Flood Wave Characteristics, Chesley J. Posey, University of Iowa

Wave Motions in the Atmosphere and Application to Forecasting, Harry Wexler, U. S. Weather Bureau

Gas Wave Analogies in Open Channel Flow, Arthur T. Ippen, Lehigh University

Thursday, June 4, 9:00 a.m.

Engineering Aspects of Fluid Turbulence

Turbulence in the Atmosphere, C. G. Rossby, University of Chicago

The Role of Turbulence in River Hydraulics, A. A. Kalinske, University of Iowa

Evaporation Studies, C. W. Thornthwaite, Soil Conservation Service

Mixing Characteristics of Density Currents, Robert T. Knapp, California Institute of Technology

Thursday, June 4, 1:30 p.m.

Sediment Transportation

The Effect of Turbulence in Retarding Settling, Thomas R. Camp, Massachusetts Institute of Technology

Fundamental Aspects of Sediment Characteristics, W. C. Krumbein, University of Chicago

Bed Load Transportation in Rivers, H. A. Einstein, Soil Conservation Service

Wind Influences on the Transportation of Sand, Helmut Landsberg, University of Chicago

There are indications that the second conference will attract as notable a gathering of engineers as did the first of this conference series in 1939. Dormitory and hotel accommodations will again be arranged for those attending the sessions, and in addition one of the large fraternity houses on the University Campus will be open exclusively to conference guests. Reservations may be made in advance by writing to Prof. J. W. Howe, Engineering Building, University of Iowa, Iowa City.

Library Board Revises Book-Loan Rules

FOR several years members of The American Society of Mechanical Engineers have enjoyed the privilege of borrowing books from the Engineering Societies Library, located in the Engineering Societies Building, New York. Many have made use of this service. Books have been sent all over the country and are being sent in increasing numbers.

As a result of experience, the Library Board has just modified the rules by reducing the fee charged to cover mailing and other costs involved in this service.

Under the new rules, books will be loaned to any member in the United States or Canada upon request. A charge of twenty-five cents a volume is made and the loan is for one week. It may be kept another week by paying a second twenty-five cents.

Excepting rare and irreplaceable books and such purely reference books as dictionaries, handbooks, etc., all treatises and textbooks may be borrowed.

As the library is equipped to supply photostat and microfilm copies of periodical articles, periodicals are loaned only when bound and then only when these reproductions will not answer the need.

There is no printed catalogue of the Library, but inquiries as to what can be supplied on any subject will be gladly answered.

A.S.M.E. Heat Transfer Division to Hold Symposium Jointly With A.I.Ch.E., Boston, May 13

Members of A.S.M.E. Welcome to Attend All Sessions

IN CONNECTION with the 1942 semi-annual meeting of the American Institute of Chemical Engineers, to be held at the Hotel Statler, Boston, Mass., May 11, 12, and 13, there has been announced a symposium on heat transfer that has been arranged jointly with the Heat Transfer Division of The American Society of Mechanical Engineers.

Prof. W. H. McAdams to Preside

The symposium, to which nine papers have been jointly contributed, will be held on Wednesday, May 13, starting at 9:30 a.m. and running throughout the entire day. W. H. McAdams, professor of chemical engineering at the Massachusetts Institute of Technology, will preside.

Members of the A.S.M.E. may attend all sessions of the Institute's meeting and the banquet to be held on Tuesday evening and participate in other social events, by presenting their A.S.M.E. membership cards at the registration desk.

Copies of the program, which will contain abstracts of the papers of the entire meeting, have been mailed to members of the A.S.M.E. Heat Transfer Division. The Institute plans to publish all papers in June and arrangements are being made whereby copies may be purchased by A.S.M.E. members at special rates.

Papers in Symposium

The program of the Joint Symposium of the Institute with the A.S.M.E. Heat Transfer Division is as follows:

9:30 a.m.

Manufacture of Silica Aerogel, Description of Process and Heat-Transfer Problems, by J. F. White, research department, Merrimac Division, Monsanto Chemical Company, Boston, Mass.

10:00 a.m.

Condenser Subcooler Performance and Design, by A. P. Colburn, L. L. Millar, and J. W. Westwater, University of Delaware, Newark, Del.

10:30 a.m.

A Simplified Heat-Transfer Correlation for Semiturbulent Flow of Liquids in Pipes, by R. H. Norris, general engineering laboratory, and M. W. Sims, consulting engineering laboratory, General Electric Company, Schenectady, N. Y.

11:00 a.m.

Heat-Transfer and Pressure Drop for a Fluid Flowing in the Viscous Region Through a Vertical Pipe, by R. C. Martinelli, University of California, Berkeley, Calif.; C. J. Southwell, Standard Oil Company, San Francisco, Calif.; G. Alves, Lieut., U. S. Army, Ordnance Division, Ogden, Utah; H. L. Craig, Procter and Gamble Company, Cincinnati, Ohio; E. B. Weinberg, N. F. Lansing, and L. M. K. Boelter, University of California, Berkeley, Calif.

11:30 a.m.

Radiant Heat Transmission From Water Vapor, by H. C. Hottel and R. B. Egbert, Massachusetts Institute of Technology, Cambridge, Mass.

2:00 p.m.

Transfer Processes in Annuli, by J. H. Wiegand, Experimental Station, E. I. du Pont de Nemours & Company, Wilmington, Del., and E. M. Baker, University of Michigan, Ann Arbor, Mich.

2:30 p.m.

Heat-Transfer by Convection in Annular Spaces, by C. C. Monrad, Carnegie Institute of Technology, Pittsburgh, Pa., and J. F. Pelton, Linde Air Products Company, Tonawanda, N. Y.

3:00 p.m.

Heat-Transfer From Wires to Air in Parallel Flow, by A. C. Mueller, E. I. du Pont de Nemours & Company, Wilmington, Del.

3:30 p.m.

Application of an Electric Model to the Study of Two-Dimensional Heat Flow, by M. Avrami, instructor in metallurgy, and V. Paschkis, research associate in mechanical engineering, Columbia University, New York, N. Y.

Procedure of A.S.M.E. Standardization Committee of General Interest

AT its meeting on Dec. 1, 1941, the Standardization Committee of The American Society of Mechanical Engineers included in its minutes a statement of its procedure which is of general interest to engineers.

The Committee has been in continuous existence since April, 1911. With the organization of the American Standards Association in October, 1918, the early procedures of the committee were, of necessity, considerably modified and since that date the A.S.A. procedures have been changed from time to time in the light of experience. The following paragraphs outline briefly the principal functions of the committee as at present recognized.

Principal Functions of Committee

1 To initiate from time to time standards projects which when approved by the A.S.M.E. Council are transmitted to the American Standards Association.

2 To review all proposals for standardization projects which are to be initiated by the Society under the procedure of the A.S.A. If approved by the committee they are submitted by it to the Council. At this time the recommendations will cover also the question of sponsorship or joint sponsorship.

3 To review all proposals for co-operation of the A.S.M.E. in the work of standards committees initiated by other societies or associations. If approved by the committee they are submitted by it to the Council.

4 To make recommendations on all appointments of the official representatives of the Society on sectional committees organized under the procedure of the A.S.A. and other special standards committees. The appointments are made by the president of the Society on the nomination of the A.S.M.E. Standardization Committee.

5 To assume responsibility for the progress made by the technical groups where the Society holds sole sponsorship and to be jointly responsible under joint sponsorships.

6 To facilitate that work in every way possible through the activities of its secretary and to keep in close touch with the developments of the several projects sponsored by the Society.

7 To review final drafts of proposed standards at the time of the letter ballot of the sectional committee. When the proposed standard is mailed to the members of a sectional committee for vote on approval by letter ballot copies are sent also to the members of the A.S.M.E. Standardization Committee for critical comment on its technical content. Any criticism or comment which its members may have as individual members of the Society are then sent promptly to the A.S.M.E. official representatives on the sectional committee in question for their guidance in voting on the proposed standard.

8 To initiate the approval of standards by the A.S.M.E. when the proposed standard comes to the Society for vote on approval as a sponsor or joint sponsor with the official letter of transmittal, the committee examines and reports on the basis of:

(*a*) Personnel of technical committee (adequacy of representation)

(*b*) Procedure followed by technical committee, including publicity

(*c*) Result of the letter ballot vote of the technical committee

(*d*) General satisfaction of the mechanical-engineering profession with the proposed standard.

9 Each year in October the committee submits its annual report to the Secretary and the Council of the Society together with an abstract for insertion in the Secretary's report to the Council.

10 In November the Committee nominates a member of the Society for appointment by the incoming president as the new member of the committee.

THE SPEAKERS' TABLE AT THE DINNER, A.S.M.E. SPRING MEETING, HOUSTON, TEXAS
(Left to right: Eugene W. O'Brien, Col. James L.Walsh, Frank H. Prouty, Brig. Gen. Earl McFarland, and William M. Sheehan.)

A.S.M.E. Discusses the Mechanical Engineer in the War at Semi-Annual Meeting, Houston, Texas, March 23–25, With Students of Southwest in Attendance

MORE than six hundred members, students, and guests registered at the 1942 Spring Meeting of The American Society of Mechanical Engineers held at the Rice Hotel, Houston, Texas, March 23–25.

At the first national meeting of the Society since formal entry of the United States into the war, the program and particularly the addresses at the luncheon and dinner reflected the direct and overwhelming concern of mechanical engineers with the conversion of peacetime industry to war production as well as subjects of normal national and regional interest. Sessions on aviation subjects attracted exceptionally large audiences, as did those devoted to problems of war production and plant management. Regional interest in the petroleum industry naturally accounted for three sessions sponsored by the Petroleum Division, at one of which the most recent John Fritz Medalist, E. L. DeGolyer, Deputy Director of Conservation, Office of the Petroleum Co-Ordinator for National Defense, Washington, D. C., spoke on "Petroleum Conservation in the War Effort."

At the dinner, which attracted nearly four hundred persons, Brigadier General Earl McFarland, assistant to the Chief of Ordnance, War Department, Washington, D. C., delivered the principal address, "The Mechanical Engineer in War," the text of which appears in this issue. Col. James L. Walsh, chairman of the A.S.M.E. War Production Committee, ably carried on the theme set by General McFarland with an inspiring address, "Logistics—the Problem of Delivering the Goods," in which he brought home to all listeners the importance of the tasks which confront all citizens especially mechanical engineers in backing up the armed forces in the winning of the war. Colonel Walsh's address also appears in this issue.

The Southwestern Student Meeting of Group 7, of the A.S.M.E. Student Branches, which was held simultaneously with the A.S.M.E. Spring Meeting, afforded not only a program of student papers and plant visits but also an opportunity for student members of the A.S.M.E., of whom more than 200 were in attendance, to listen to papers and discussions that constituted the Society's program and to join with the Society at the banquet, where awards for the prize-winning student papers were announced.

In spite of the difficulties which the war has placed in the way of visits to plants where work of interest to mechanical engineers is in progress, arrangements were successfully completed for a full day, Wednesday, devoted to trips by bus to the Hughes Tool Company and to the Houston shipyard.

A special program of entertainment for the women included a sight-seeing trip in Houston, a fashion show and tea at the Junior League, and a trip to the San Jacinto Battlefield, with luncheon at the San Jacinto Inn.

The Technical Program

The technical program which consisted of 15 sessions, began on Monday afternoon with the presentation of papers on domestic gas-fired floor furnaces, natural gas, the operating characteristics of fluid-actuated pumps, pumping equipment for oil-well cementing, textile engineering and what it means to the Southwest, and the mechanical harvesting of cotton as influenced by varietal characteristics.

Monday evening afforded opportunity for four simultaneous sessions on marine power, petroleum, corrosion, and war production. Papers were presented on marine boilers, the effect of valve-seat deflection, design of oil-field tank batteries from a conservation viewpoint, petroleum conservation in the war effort, protection of buried metals against corrosion, the application of cathodic protection for corrosion prevention, and the development work of the Ordnance Laboratory at Frankford Arsenal. An illustrated "sound" lecture on design of steel castings, which was followed by a discussion led by W. M. Sheehan, assistant vice-president, General Steel Castings Corp., was a feature of the War Production Session.

The three sessions of Tuesday morning were devoted to the training of labor for production, aviation, and heat transfer. At the labor-training session the subject was "New Responsibilities for Labor," presented by H. W. Acreman, executive secretary, Texas State Federation of Labor, Austin, Texas; J. R. Steelman, director, U. S. Conciliation Service, U. S. Department of Labor, Washington, D. C., and T. M. Davis, attorney, Houston, Texas. Dr. Steelman was represented by Clarence Williams, Commissioner of Conciliation.

Keeping ahead of aviation development and a résumé of activities of research laboratories of the National Advisory Committee for Aeronautics were the subjects of papers at the aviation session, and pictures of the Sikorsky VS-300 helicopter were shown. Three

papers were presented at the heat-transfer session on a review of heat-transfer coefficients and friction factors for tubular heat exchangers, condensation of saturated Freon-12 vapor on a bank of horizontal tubes, and heat transfer, pressure drop, and fouling rates for continuous and noncontinuous longitudinal fins.

After luncheon on Tuesday, five simultaneous sessions were held on small-plant management, heat-recovery equipment and flash-freezing of foods, fuels, petroleum, and aviation. Two of the papers at the heat-recovery session dealt with operation and maintenance of air preheaters and a method of selection of optimum-size economizers and air preheaters. The third described quick- and flash-freezing of foods and the fundamental theories and applications of the various processes involved.

The fuels session was a round-table discussion of trouble shooting on gas and oil burners, to which a number of prominent engineers contributed. A sound film, "Design and Construction of Steam Generating Units," was also presented at this session.

At the petroleum session the subjects of the papers were the metering of petroleum products as a measure of national defense and the automatic control of natural-gas-fired power boilers.

John E. Younger, chairman of the A.S.M.E. Aviation Division, presented a discussion, "Building Tomorrow's Airplanes Today," at the aviation session and J. L. Atwood, executive vice-president, North American Aviation, Inc., Inglewood, Calif., spoke on problems in the aircraft-manufacturing industry. Jerome F. Lederer, director, Safety Bureau, Civil Aeronautics Board, Washington, D. C., described some motion pictures used in accident analysis.

Engineers Speak at Luncheon

On Tuesday noon E. L. Henderson, president, Houston Engineers' Club, presided at the general luncheon, and C. L. Orr, chairman, A.S.M.E. South Texas Section, acted as toastmaster.

Mr. Henderson extended a brief message of greeting to the visiting members of the A.S.M.E. and said that he was glad to see that so many engineers had come to the meeting at Houston to get acquainted and to exchange ideas, which would, he was sure, make them better equipped to carry on the tasks that lay before them.

Mr. Orr thanked the Houston Engineers' Club for changing the date of its regular luncheon meeting so that it could meet with the visiting members of A.S.M.E. He introduced the distinguished guests at the speakers' table and referred to the death of Alex Dow, former president and honorary member of the A.S.M.E. Mr. Dow's sudden death, he explained, had made it necessary for his son-in-law, James W. Parker, president A.S.M.E., to cancel his visit to Houston and his engagement to speak at the luncheon. He then introduced Frank H. Prouty, vice-president, A.S.M.E., who said that the substance of Mr. Parker's message, telephoned to him, had been that it was not the name of the Society but individual engineers who composed the Society, that should be exploited.

Mr. Prouty spoke of the importance of production for the war effort and of the manner in which a shortage of engineers was being met by intensive training in short courses offered by the engineering schools. It was a mechanized war that the nation had engaged to win and the nation was looking to engineers to provide more and better war machines, he said.

In so far as opportunities for engineers after the war were concerned, there would be plenty, in his opinion. At the risk of expressing ideas that some might think fantastic, he would suggest, he said, that new applications of electricity would be developed. The potential opportunities for engineering and research that lay in electricity were enormous. The national use curve of electricity was going up all the time. Might we look forward someday, for example, to the application of electricity to airplane flight? Might some way be found by which rainfall could be diverted to water such places as the desert areas of Australia? What chance was there of tapping for practical use the great store of energy in the sun? These particular developments might not be the ones to engage the attention of engineers in the immediate future, but surely others would develop. The engineer and the merchant would combine with the scientist to devise new sources of wealth whereby our rapidly rising national debt would be retired. In this task, he said, there would be plenty of opportunity for the mechanical engineer.

Mr. Orr then introduced Prof. Henry E. Riggs, past-president of the American Society of Civil Engineers, who graciously acknowledged the applause that greeted him.

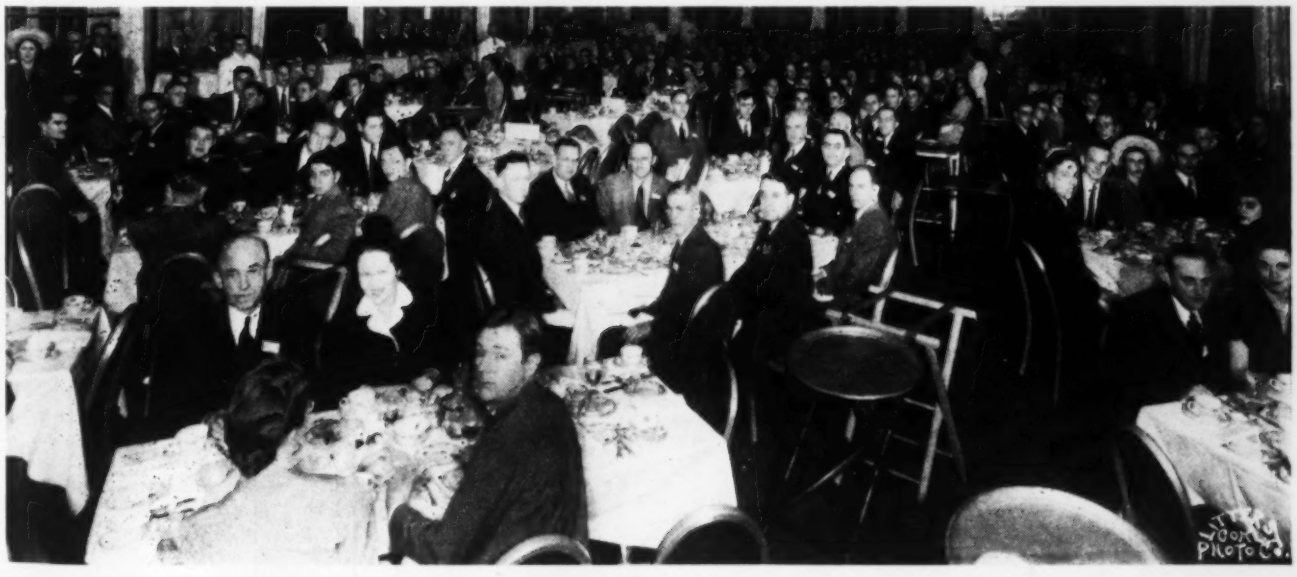
Dean James M. Robert, of Tulane University, then spoke in an amusing manner and delighted his audience with a number of well-told stories. He charged his audience to remember that it was only in the exchange of ideas that a man could give something away and yet retain it.

Colonel Tuttle Talks on Texas

Speaking on the subject, "The Eyes of the Nation Are on Texas," Col. William B. Tuttle, member A.S.M.E., chairman of the board of directors, San Antonio Public Service Company, San Antonio, Texas, attempted to sketch in the brief time allotted to him some of the natural resources of his great state and to tell particularly visitors from outside the state some of the present and future contributions of the state to the nation's wealth and life. The potential resources of Texas, he said, were greater than those of any other state of the nation and offered amazing opportunities for engineers.

Vice-President Prouty Toastmaster at Banquet

The dinner on Tuesday evening, at which Frank H. Prouty, vice-president of the Society, acted for President Parker in the capacity of toastmaster, was attended by nearly four hundred persons. Among these was a considerable number of students, including a group



AT THE DINNER, A.S.M.E. SPRING MEETING, HOUSTON, TEXAS

who were guests of the A.S.M.E. "Old Guard," an organization of members under the leadership of Harte Cooke who had paid Society dues for more than thirty-five years and who acknowledge the value of this privilege by assisting student members in various ways.

Mr. Prouty, after having introduced the persons seated at the speakers' table, turned the exercises over to song leader Walter Jenkins, of Houston, who, with the assistance of Mrs. Jenkins, a pianist, and a male quartet, got the entire company to join in the singing of familiar songs, with intervals of specialty numbers rendered by members of his group.

Student Prize Winners Announced

After the interlude of song, Howard E. Degler was called upon to announce the winners of the student-prize papers. Simultaneously with the A.S.M.E. Spring Meeting, representatives of the ten engineering colleges constituting the Southwestern Student Branches of Group VII had been holding its annual conference at which papers were read throughout three technical sessions. A board of judges had come to a decision regarding the excellence of the papers presented and had awarded eight prizes representing $170 in cash and two volumes of Kent's "Mechanical Engineers' Handbook."

The host branch of the 1942 Conference was the University of Oklahoma, and the committee was made up of J. R. Lesch, chairman, F. L. Spencer, secretary, and L. H. Cherry, honorary chairman. The A.S.M.E. Student Branches which constitute Group VII are: University of Arkansas, Louisiana State University, Oklahoma A.&M. College, University of Oklahoma, Southern Methodist University, Rice Institute, A.&M. College of Texas, Texas Technological College, University of Texas, and Tulane University.

The following prizes were donated:

First prize, $50, The American Society of Mechanical Engineers.

Second prize, $40, New Orleans A.S.M.E. Local Section.

Third prize, $25, Houston A.S.M.E. Local Section.

Fourth prize, $20, J. H. Sengstaken, Air Preheater Corporation.

Fifth prize, $15, Houston A.S.M.E. Local Section.

Sixth prize, $10, A.S.M.E. "Old Guard."

Seventh prize $10, Dallas A.S.M.E. Local Section.

Eighth prize, Kent's "Mechanical Engineers' Handbook."

The prize winners and the titles of the papers for which the prizes were awarded were:

1 Vaughan Connor, University of Texas, "The University of Texas Polyphase Quick-Freezing Machine."

2 Robert C. Borman, University of Arkansas, "Progress in Instrument Flying and Landing."

3 John Mooney, Texas Technological College, "The Effect of Water Velocity Upon Heat Output of Convectors."

4 L. L. Blake, Jr., Rice Institute, "Metal Spraying."

5 William Rudolph, Tulane University, "Arc Welding in Shipbuilding."

6 George H. Gwin, A.&M. College of Texas, "The Engineer's Part in Postwar Reconstruction."

7 John L. Martinez, Tulane University, "Fundamentals of Airfoil Design."

8 John McEwin, Texas Technological College, "The Calibration of the Leftwich-Wilson Automatic Vacuum Pump."

PRIZE WINNERS AT THE A.S.M.E. STUDENT MEETING OF THE SOUTHWEST GROUP HELD IN CONJUNCTION WITH THE SPRING MEETING OF THE SOCIETY AT HOUSTON, TEXAS

[Seated, left to right: Vaughan Connor (first prize) University of Texas; Robert C. Borman (second prize) University of Arkansas. Standing, left to right: William Rudolph (fifth prize) Tulane University; John Mooney (third prize) Texas Technological College; L. L. Blake, Jr. (fourth prize) Rice Institute; John McEwin (eighth prize) Texas Technological College; George H. Gwin (sixth prize, "Old Guard") A.&M. College of Texas; and John L. Martinez (seventh prize) Tulane University.]

McFarland and Walsh Give Stirring Addresses

The speaking program of the banquet consisted of addresses by Brig. Gen. Earl McFarland, assistant to the Chief of Ordnance, Washington, D. C., whose subject was "The Mechanical Engineer in War," and Col. James L. Walsh, chairman A.S.M.E. War Production Committee, New York, N. Y. Colonel Walsh spoke on "Logistics—the Problem of Delivering the Goods." General McFarland was introduced by William M. Sheehan, member A.S.M.E., assistant vice-president, General Steel Castings Company, and Colonel Walsh by Eugene W. O'Brien, vice-president and managing director, W. R. C. Smith Publishing Co., Atlanta, Ga., past vice-president A.S.M.E. The texts of the two addresses appear in this issue.

Before introducing Colonel Walsh, Mr. O'Brien referred with tact and graciousness to a regrettable error that had occurred during the awarding of prizes for the student papers. The name of Samuel J. Black, University of Oklahoma, had been called by mistake as winner of the fourth prize and the prize of twenty dollars had been handed to him before the startled judges could call attention to the error. With the good sportsmanship of American youth, Mr. Black returned the prize money.

After further singing by members of Mr. Jenkins' company, the dinner guests adjourned to the Empire Room of the Rice Hotel for dancing.

Houston Committees

Arrangements for the meeting at Houston were made under the general supervision of the A.S.M.E. Committee on Meetings and Program and a group of committees centered at Houston, of which C. L. Orr was chairman, H. F. Moller, vice-chairman, Joe J. King secretary-treasurer, and W. R. Woolrich honorary chairman. The Executive Committee consisted of H. E. Degler, C. W. Crawford, and H. G. Hiebeler.

Subcommittees were as follows:

Hotel and Program: H. E. Degler, chairman, V. M. Faires, H. F. Godeke, C. A Hall, F. E. Justice, H. F. Moller, Ralph Neuhaus, and B. E. Short.

Reception and Registration: C. L. Orr, chairman, W. T. Alliger, J. W. Beretta, H. E. Chambers, C. W. Crawford, H. W. Fletcher, W. Bres Gregory, G. G. Harrington, Nathan Janco, Joe J. King, M. H. Kotzebue, F. M. Leverett, R. M. Matson, W. A. McDonald, H. R. Pearson, J. H. Pound, F. D. Rahm, J. M. Robertson, and E. F. Schmidt.

Group 7 Student Meeting: L. H. Cherry, chairman, V. L. Doughtie, H. L. Kipp, L. C. Price, C. H. Shumaker, H. W. Waterfall, and V. W. Young.

Plant Trips: W. B. Preston, chairman, M. L. Begeman, E. J. Daasch, H. G. Hiebeler, S. G. Kershner, G. E. Nevill, C. L. Orr, A. D. Stark, and M. W. Williams.

Ladies Events: Mrs. H. G. Hiebeler, chairman, Mrs. J. W. Beretta, Mrs. H. E. Degler, Mrs. V. M. Faires, Mrs. W. Bres Gregory, Mrs. S. G. Kershner, Mrs. Joe J. King, Mrs. C. L. Orr, Mrs. W. B. Preston, and Mrs. J. M. Robertson.

A.S.M.E. Detroit Section Pays Tribute to Alex Dow at Meeting Describing Shell-Turning Machine He Suggested

ONE hundred and eighty members and guests attended the April 7 meeting of the A.S.M.E. Detroit Section in the small auditorium of the Horace H. Rackham Memorial. Over one hundred had attended dinner prior to the meeting.

In opening the session, the chairman, A. M. Selvey, pointed out the importance of the evening's subject in that the country was at war and needed an ever-increasing output of shells, and that the machine to be described was largely the outcome of the vision and foresight of the late Dr. Alex Dow, Fellow, Honorary Member, and Past-President of the Society, who had passed away only a few days previously. The chairman spoke of the sincere respect in which Dr. Dow was held by both the local and national membership. In behalf of the Society, Prof. A. E. White of the University of Michigan gave before a standing audience the valediction to Dr. Dow.

Mr. Carroll R. Alden, chief engineer of the Ex-Cell-O Corporation, in introducing the evening's speaker, Christian A. Birkebak, in charge of the development of the shell-turning machine, spoke of the valuable part that Dr. Dow had freely and generously assumed in originating and perfecting this ordnance tool ahead of the present emergency.

Mr. Birkebak described the machine with the aid of slides showing different stages of construction and various details of design. This is a simple, rugged machine for ultra-rapid turning of 75 to 155-mm shells. The design, operation, and arrangement of tools were fully described. A lively discussion brought out many problems in machine tools and operation, materials handling, and lubrication.

Tribute to Alex Dow

BY A. M. SELVEY

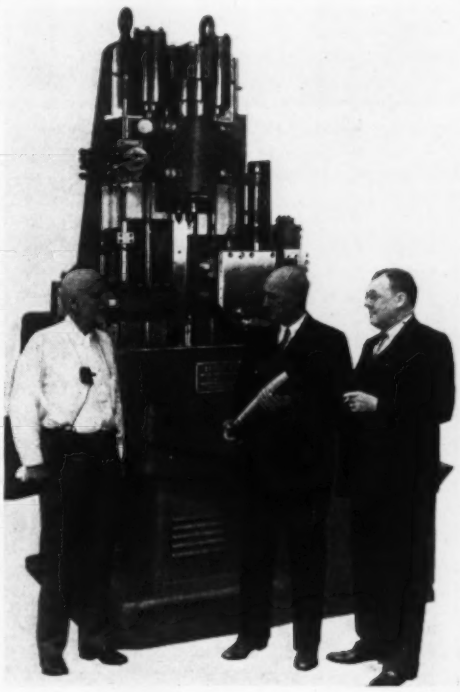
TO THE Detroit Section, and to the Society as a whole, the loss of Alex Dow is a severe one. Through his friendly personality and his expressive addresses made before innumerable Detroit and national audiences, he became known to all of us more as a friend than as an industrial executive or as one holding the highest office and honors our Society can confer, and he won a corner in all our hearts. Who of us will ever forget his ability to tell a pointed story at the proper time, or to recite from an unlimited memory some lines of beautiful poetry? We cannot take leave of him without showing our sincere respect and admiration.

His story was one of great human interest. From a poor Glasgow boy without worldly advantages but inheriting, like most Scotchmen, a strong sense of the right and a capacity for work, he rose to a position of world leadership in the engineering profession. He was an idealist, as are many of his countrymen, but he was a realist too, and therein lay his greatness. No business problem was so large, no personal problem so small, that he would not give it his careful consideration and, where he thought it necessary, formulate some equitable judgment.

Through his vision much was created of great service to the people. Tonight we are particularly interested in his work on a shell-turning machine which surpasses in production all previous records. Through his industry and co-operation with others, this machine was perfected several years ago and given to the United States Government to be ready to fill a great need when the time came.

Now he has left us to carry on. It is very right and the wish of the Society that before proceeding we pause to perform our last duty toward one who has meant so much to our community and our fraternity. The deep feeling in the minds and hearts of all of us is beautifully expressed in the following lines by Alfred Lord Tennyson:

And the stately ships go on
To their haven under the hill;
But O, for the touch of a vanished hand,
And the sound of a voice that is still!



LAST PICTURE OF DR. DOW TAKEN IN THE SUMMER OF 1941

Shell-turning machine designed by Ex-Cell-O Corporation in conjunction with Dr. Dow (left); right is Phil Huber, president, and center Thor M. Olson, vice-president of the company.)

Valediction to Alex Dow

BY A. E. WHITE

ALEX DOW, pioneer, executive, engineer, philosopher, and humanitarian, passed away on Sunday, Mar. 22, 1942, leaving behind a host of friends and an amazing number of accomplishments.

Born in Glasgow, Scotland, in 1862, and with opportunity for but six years of schooling, he rose to be one of America's great engineering leaders. He was respected and honored for his work in the utility field; for his sound guidance of The Detroit Edison Company group for 46 years, of which he was president for 28 years; for his ever-willing service to his city which he served for twelve years as a member of the Board of Water Commissioners; for his work with the War Department; and for his services to engineering-society activities.

His contributions to the utility industry were monumental. As early as 1896 he foresaw that a frequency of 60 cycles would be best for alternating-current service, a frequency which has now been almost universally adopted.

In 1898 he inaugurated the differential rate for electric service and his reasoning was so sound that practically all rate schedules in this country now embody this feature.

He was the first to adopt large boilers and, though these are extensively used today, it took courage and farseeing pioneering to authorize their construction in 1910.

His depreciation policy has won the praise of state and federal commissioners. His plant valuations, based on "original cost," which he laid down in 1912, were adopted 25 years later by the Federal Power Commission. He eliminated the "holding company" phase of The Detroit Edison Company's existence in 1915, 20 years before Congress enacted the death sentence for the holding-company idea.

These are but a few of his many accomplishments, but give undeniable proof of his intelligence and ability and account for the great respect in which he was held by all those with whom he came in contact.

Always interested in national-defense matters, he served his country without thought of self from 1932 until his death, as Chief of the Detroit Ordnance District.

He gave ungrudgingly of his time to engineering-society activities and in recognition of his achievements both the American Society of Civil Engineers and The American Society of Mechanical Engineers bestowed honorary membership on him. He was also awarded the Edison Medal by The American Institute of Electrical Engineers.

He served The American Society of Mechanical Engineers on the Special Research Committee on Thermal Properties of Steam for ten

years, six of them as chairman. He was a vice-president of the Society from 1906 to 1908 and president in 1928.

In Detroit engineering fields he was a charter honorary member of the Engineering Society of Detroit and since 1936 had been president of the trustees of the Rackham Engineering Foundation.

For his many deeds of high-minded public service, he was given by Wayne University, the University of Detroit, and the University of Michigan the highest honors within their powers.

Though Mr. Dow's deeds and services will live on through succeeding generations, those of us who had the rare privilege of knowing him personally think of him as a man and as a leader of men; one who was filled with sympathy and justice for all.

We see his scintillating personality on the platform. We remember his words of wisdom and cheer intermingled with his rare wit. We recall his vast knowledge of subjects far removed from engineering and finance. We recall his ability to converse as an equal with those profound in their knowledge of philosophy, religion, history, and kindred subjects. Yes, not only did he meet these men on their own ground, but he frequently proved to be more than their equal.

We recall his sense of fairness and justice. We recall the adoration of all those with whom he came in contact, irrespective of station or rank. These are the things Alex Dow means to us who knew him.

In his death his city, his state, and his country have suffered a genuine loss. Even though a great leader has been taken from the engineering profession and The American Society of Mechanical Engineers, in particular, Mr. Dow will live on in the hearts of his friends and in the brilliant record of his accomplishments.

Alex Dow and the Shell-Turning Machine

By CARROLL R. ALDEN

SEVEN years ago, when Mr. Huber, now president of Ex-Cell-O Corporation, was asked by the Ordnance Department to design an advanced type of lathe that would more adequately meet this country's armament needs, Mr. Birkebak was working at Ex-Cell-O in its engineering department. On carte-blanche instructions from Mr. Huber he spent many months at the Frankford Arsenal in Philadelphia—at first gathering working information so that we might go ahead with a roughing machine for producing shells faster and, later testing out both roughing and finishing machines immediately after their installation at that arsenal. At the present time, Mr. Birkebak is devoting his entire time to providing these shell-turning lathes to the many private industries producing 75 to 155-mm shells under the war program.

As all of us are well aware, machine tools like the shell-turning lathe that is to be illustrated tonight do not "just happen." They are invariably the outcome of a pressing need and considerable mechanical ingenuity. Their consistent development is often due to the influence and encouragement of those personally interested in them. This is decidedly the case with the Ex-Cell-O shell-turning machine.

It is my privilege now to speak of the man—a past-president of this Society—who originally brought this machining problem to us. I refer to Mr. Alex Dow, whose recent death is a distinct loss to this Society and to many of us personally.

On first thought it may seem a rather far cry from the affairs of a busy public-utility executive to a practical and official interest in a machine tool for government arsenals. But that is only when we forget that Mr. Dow was a man of far-flung interests, a man with an unwavering loyalty to his long-adopted country and to the community in which he lived.

For many years, he was Chief of the Detroit Ordnance District for the War Department. It was in this capacity, and also because of his familiarity with the pioneer work Ex-Cell-O was doing in the field of precision machining, that he asked our company to devise the shell-turning machine.

Mr. Dow's co-operation was always intensely practical. At his own expense, he inspected the arsenals of the United States and Canada and traveled all through Europe, including France and Germany, to acquire first-hand an idea of just what the exact needs were in shell turning. He returned with considerable data from his observations at the different arsenals in these various countries. All this knowledge he readily made available to the War Department and to us.

It is because of all this and because of many other intimate associations with Mr. Dow, that we feel our part on this occasion tonight would be lacking if we did not specifically refer to the important part he had in the development of the shell-turning lathe. Incidentally, I might add that the picture shown here of Mr. Dow is the last photograph taken of him. It was made by our photographer last summer.

Meetings of Local Sections

President Parker Addresses Baltimore on Defense Problems

AT the Mar. 16 meeting of the Baltimore Section, President James W. Parker, A.S.M.E., addressed more than 65 members and guests. His topic, "A.S.M.E. Faces a Fork in the Road," covered an outline of work of A.S.M.E. men in war industries as well as a discussion of some engineering problems arising in connection with defense work, particularly in the power and light field in the Detroit area.

The Engineer in Defense Work Subject at Birmingham Meeting

Members and guests of the Birmingham Section heard Col. A. C. Polk speak on "The Engineer in Defense Work," presenting the particular problem of red tape in defense contracts, emphasizing the need for full co-operation between civilian and military engineers. He especially commended the spirit of determination shown in accomplishing present tasks in the Army construction program and pointed out that work was progressing with all possible speed.

Record Audience at Buffalo Section Hears Clyde Mitchell

Over 300 members and guests at the Mar. 11 meeting of the Buffalo Section heard Major Clyde Mitchell, Fred Flader, and Max Stuper jointly discuss "Aircraft, Old and New." The speakers treated of the history of aircraft development, indicating effects on present designs. Major Mitchell, prominent aviation expert, gave a summary of the organization of the Air Corps. In concluding this interesting meeting, sound pictures, depicting both Bell and Curtiss aircraft production, were shown.

Students Compete for Prizes at Central Indiana Meeting

Four timely talks were made by students in competition for prizes at the Mar. 13 meeting of the Central Indiana Section. The topics, "Wing Vibration and Flutter," "Locomotive Speedometer," and "High-Speed Indicators" contributed to an absorbing and novel meeting.

High Pressures Featured at Central Pennsylvania

More than 200 members and guests of the Central Pennsylvania Section heard Dr. P. W. Bridgeman, professor of mathematics and natural philosophy at Harvard University, at the Mar. 4 meeting. Professor Bridgeman was brought to the campus under the co-operative sponsorship of the Society of the Sigma Xi and the Section. He described the steps by which measurable laboratory processes have been successively raised from 3000 atmospheres to 4,000,000 atmospheres or 6,000,000 psi. At such extremely high pressures, polymorphic transition is a common phenomenon. Dr. Bridgeman then proceeded to explain changes in properties of materials under extreme pressure.

At its second March meeting, held on Mar. 24, the Section had as its guest speaker Prof. Chas. E. Gus, whose topic was "Teaching with Animated Cartoons." The theme of the talk was the use of animated cartoons as a visual aid to teaching; in addition, Professor Gus discussed the development and manufacture of these cartoons and finally presented several of his own dealing with engineering topics.

Cleveland Engineers See Sound Film on Generators

More than 75 members and guests at the Mar. 12 meeting of the Cleveland section were

privileged to see "The Design and Construction of Riley Steam Generators," a sound film with comments handled by J. W. Armour, Detroit district manager of the Riley Stoker.

Rubber and Oil Spotlighted at Colorado Meeting

The pressing subjects of oil and rubber furnished material for the Mar. 24 meeting of the Colorado Section. Three speakers, R. E Hartman, H. A. Stewart, and R. F. Throne handled the topics of "Synthetic Rubber Vs. War," "Oil Production in Columbia and Venezuela," and "Know Your Scrap Pile," respectively. Mr. Hartman gave an up-to-the-minute résumé of the rubber situation, including facts and figures. He described the manufacture of synthetic rubber from butane, commenting on design, costs, time, etc. Mr. Stewart's talk on oil in Columbia and Venezuela was illustrated with color slides and movies. The last speaker emphasized the importance of evaluating our scrap in all its aspects. This varied program was greatly enjoyed by all who heard it.

Columbus Engineers Discuss Pressure Cabin Airplane

To an audience of more than 80 members and guests, Dr. John E. Younger talked on "The Development of the Pressure Airplane for Altitude Flying" at the Apr. 3 meeting of the Columbus Section. He spoke of the development of the airplane for stratosphere flying and told how some of these problems were solved. His talk provoked much favorable and lively comment.

Dual Program Presented at Detroit Section

A receptive audience of 125 members and guests, on Mar. 23, at a Detroit Section Meeting, heard Otto Lorenzi, Combustion Engineering Co. He discussed moving pictures showing the burning of coal on stokers and described the operation of underfeed, chain-grate, and spreader-type stokers. He further illustrated the effect of furnace design by moving pictures taken through observation doors in various furnaces. The other speaker of the evening, Inspector Edward Jurgens, director of traffic for the City of Detroit, pointed out the tremendous loss of life, property, and time through accidents, most of which are preventable by proper co-operation of the public, more strict enforcement of the laws, and the education and maintenance of public interest in the official emergency-traffic-law enforcement program.

Home Defense Topic at East Tennessee Meeting

On Mar. 5, members and guests of East Tennessee Section heard Maxwell C. Maxwell speak on the present important topic of home defense, or the use of locks to protect the home.

Powder Metallurgy at Fort Wayne Section

Powder metallurgy was the subject at the Mar. 19 meeting of the Fort Wayne Section. More than 70 members and guests heard R. P. Koehring outline its history and then describe the preparation and properties of various metal powders. Slides were displayed, portraying the manufacture of bearings and precision-molded metal pieces. The topic was further vivified by display boards showing many pieces made by the powdered-metal process.

Greenville Hears About Combustion of Fuel

An excellent lecture on Mar. 5 was the feature of the evening at Greenville Section. E. M. Williams, member of Greenville Section, A.S.M.E., presented, in addition to his lecture on "Combustion of Fuel," illustrative films on his subject. The entire evening was greatly enjoyed by all present.

Kansas Engineers Turn Medicos

An unusual departure, at the Mar. 20 meeting of the Kansas Section, was the presentation of Dr. John Hashinger, professor of clinical medicine at the University of Kansas Hospitals, as speaker of the evening. He chose as his topic "Our Endocrine Glands" and illustrated it with slides. The proof of his successful reception was the deluge of questions following the termination of his talk.

Mid-Continent Section Holds Impromptu Meeting

An interested audience of more than 60 members and guests enjoyed the Mar. 26 meeting of the Mid-Continent Section. In the unavoidable absence of President James W. Parker, two members made short talks, after which some appropriate engineering films were shown.

A.I.E.E. and A.S.M.E. Hold Meeting at Minnesota

The Mar. 30 meeting of the Minnesota Section was held jointly with the A.I.E.E.; James F. Barton was speaker of the evening. His talk, "Characteristics and Uses of Electric Sheet Steel," was illustrated with slides showing the various stages in the manufacture of sheet steel and the relation and characteristics of the various steels used for electrical purposes. The meeting closed with an open-forum discussion.

Aircraft Structures Featured at North Texas

On Mar. 31, North Texas Section heard Dr. John E. Younger on the topic of "Trends of Development of Aircraft Structures." The meeting proved one of the best of this year, the audience being particularly interested in Dr. Younger's discussion of the aircraft of the future and industry's use of new metals, such as beryllium.

A Bow to the Ladies at Ontario Meeting

Ladies' Night was held on Mar. 12 by Ontario Section. E. R. Gauley, managing editor of *Plant Administration* and *Sanitary Engineer*, presented "From Kitchen Mechanic to War Worker." He described training methods as applied to the war emergency training program whereby women are educated for war industry.

Employer and Employee Discussed at Philadelphia

To an interested audience of 100 members and guests on Mar. 24, at a Philadelphia Section meeting, Dr. C. Canby Balderson, dean of Wharton School, University of Penn., outlined "The Relation of Employer to Employee in Wartime Industry." He discussed such problems as multiple shift and compensation to employees, especially small increases which keep pace with increases in living costs rather than larger increases at greater intervals, and expressed the opinion that the former were the only increases justified and that earmarked bonuses were always easier to remove than general increases.

Providence Learns About New Navy Armament

More than 130 members and guests at the Mar. 13 meeting of the Providence Section heard Capt. A. S. Hickey, U. S. Navy, speak about new armament.

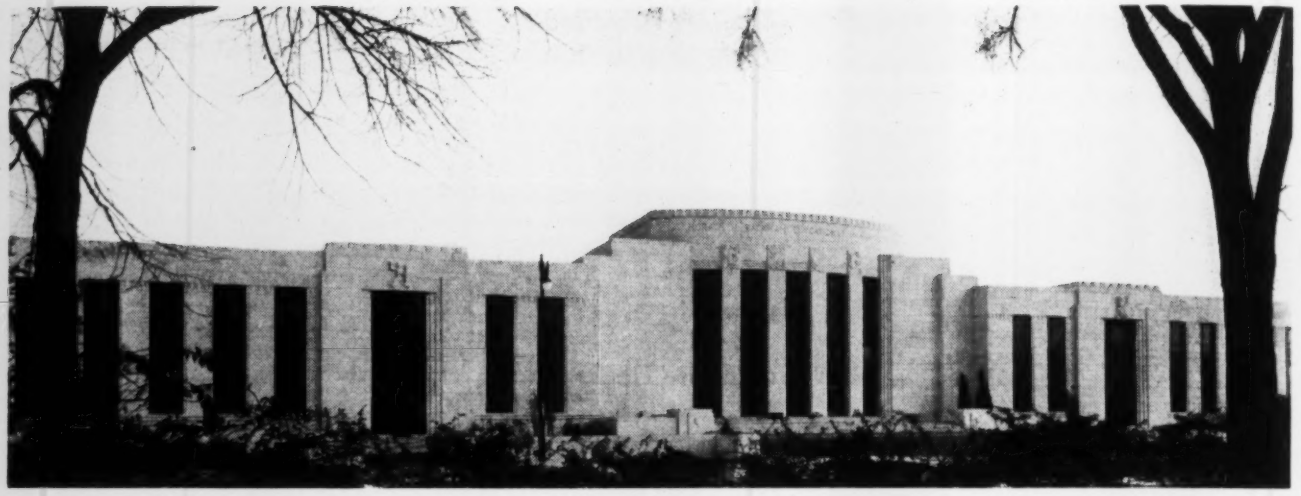
Rock River Valley Sees Film on Painting Factory Equipment

The Mar. 19 meeting of Rock River Valley Section starred a film, prepared by du Pont, on the painting of factory equipment and machinery. The film was prepared to present the results of extensive survey and experimentation conducted by du Pont in collaboration with several manufacturers in an effort to ascertain color schemes to be used in manufacturing areas to produce the best working conditions and most efficient operation.

Transportation Forum at San Francisco Section

The Mar. 24 meeting of San Francisco Section was characterized as a transportation forum, which was composed of a board of experts as follows: Aeronautics, R. W. Beecher of Pan-American Airways; automotive, C. R. Stanley, Pacific Gas and Electric Co.; marine, P. L. Joslyn, of Joslyn and Ryan, consulting engineers; electrical railway, J. H. Williams, General Electric Co.; and railroads, M. P. Taylor, Southern Pacific Co. A lively discussion of problems in each division

(*Continued on page 418*)

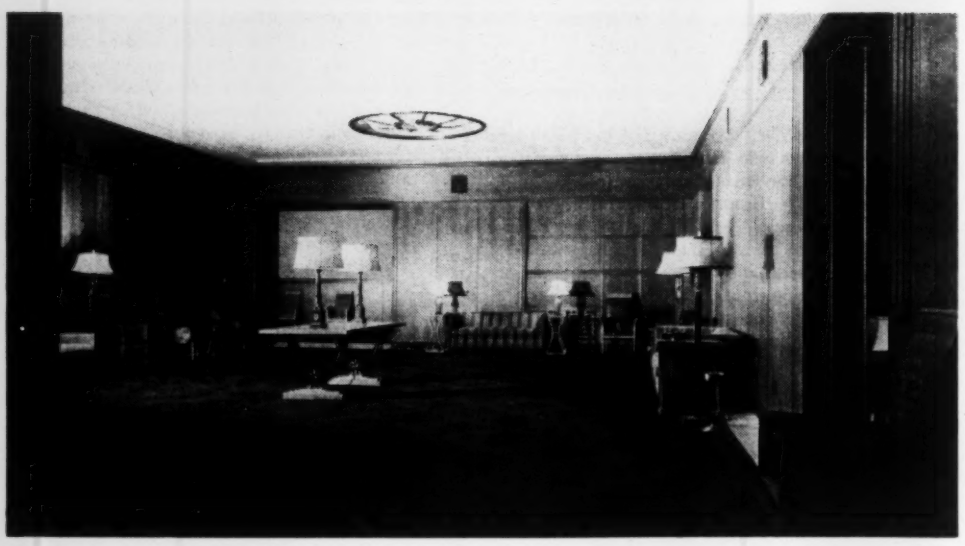


ENTRANCE TO RACKHAM MEMORIAL

(Dedicated to help men live more useful and abundant lives. In this single building are centered operating facilities for programs of Engineering Society of Detroit, Detroit office of the University of Michigan Extension Service, and Institute of Public and Social Service.)

ENGINEERS' LIBRARY

(Paneled in rift oak and lighted to a uniformly high level, this quiet place of study is provided with the services of a research librarian.)



THE LOBBY

(This is the general circulation heart of the Engineers' Unit and provides access to the auditorium, writing room, lounge, women's lounge, gallery to the dining room, and to stairways.)

The Horace H. Rackham Educational Memorial—

A.S.M.E. NEWS

THE ENGINEERS' LOUNGE

(The warm natural-walnut paneling of the spacious lounge is made more beautiful by the varicolored Porta Santo marble of the fireplace at the end of the room. The mural above the fireplace was especially designed and painted for this room by Zoltan Sepeshy.)

ENGINEERS' DINING ROOM

(The graceful combination of full-length windows, of bleached walnut wainscot, and lighting-fixture domes has been complemented by the gay mural designed for this room by Clifford West.)

TRIPLE-UNIT COMMITTEE ROOM

(To provide for large meetings, movable partitions quickly transform a group of smaller rooms into one large, completely harmonious unit.)

Headquarters of the Engineering Society of Detroit

of transportation was followed by even livelier questions, with those on aviation and gliders proving most provocative.

Ladies' Night Provokes Universal Appeal at Southern California

A ladies' program was the main feature of the Mar. 19 meeting of Southern California Section, formerly called the Los Angeles Section. More than 131 members and guests heard a varied program which held the audience's rapt attention. J. A. Cortlett, publicity representative, General Electric Co., gave a talk on "Analyzing Postwar Problems in Industry," illustrated with slides, in which the relation of a single company to the whole industry, and to the entire economic setup, was outlined. Edward B. L. Cunningham spoke on "The Far East Situation." Dr. D. W. Hoerig discussed "Scale and Corrosion Sabotage War Production." An illustrated lecture which treated of scale and corrosion control and the products for said control whose behavior can be predicted and interpreted in terms of sound chemical knowledge. Dr. Rene Belle addressed the audience on "The Defeat of the French Democracy," in which he outlined the industrial situation in France prior to World War II and its contribution to national collapse.

St. Louis Informed on Water Problems

An excellent meeting attended by more than 100 members and guests of St. Louis Section heard Dr. Ralph E. Hall, on Feb. 26. His topic was "Modern Technique in Attacking Industrial Water Problems," and revealed the effects of water and iron reactions resulting in corrosion of boiler steels. Several new viewpoints were given regarding carry-over and corrosion conditions.

Magnetic Waves Interesting to Susquehanna Section

The Mar. 6 meeting of Susquehanna Section starred Dr. E. D. Condon, who spoke on "Magnetic Waves." His talk consisted of a short history of magnetic waves, in addition to a simple scientific explanation as to definition of microwaves and their production and use.

Another high light of the evening was the presentation by Prof. A. G. Christie of a Fifty-Year Badge to Gordon Campbell, member of the A.S.M.E. since 1891 and president of the York Railway Co., until his recent retirement. The Susquehanna Section was proud to honor such a competent engineer, able administrator, distinguished executive, and worthy citizen.

Syracuse Members Honor Fifty-Year Member

The Mar. 27 meeting of the Syracuse Section honored W. E. Hopton, upon whom was conferred the Fifty-Year Badge. The first speaker of the evening was Dr. Willis Carrier, who gave a fascinating account of how, as a young electrical-engineering graduate from Cornell, he had been given some testing assignments by the Buffalo Forge Co. relating to the actual heat output of blast coils. This led to his epoch-making paper on the topic in 1911. John Hildreth, another Fifty-Year Member, then said a word of greeting, followed by E. N. Trump, 62 years in the society, and only living charter member, who gave a vivid picture of the influence of Professor Sweet and A.S.M.E. on his lifework. This meeting was most enthusiastically received by the members.

Lecture on Explosives at Washington Section

A record audience of 125 members and guests at the Mar. 11 meeting of the Washington, D. C. Section heard Dr. Wilbert J. Huff speak on the topic, "Explosives." He traced the development of commercial explosives and their use. The peculiar requirements for mining explosives were then described and through slides and pictures explosive tests shown.

Magnesium From Sea Water at Western Massachusetts

The excellent meeting of Massachusetts Section on Mar. 17 concerned itself with "Extraction of Magnesium Metal From Sea Water," as delivered by Otis E. Grant, Dow Metal Co. The speaker traced the history of magnesium production from its discovery by Davy in 1808, through 50 years of experimentation, up to present-day production. In 1915, the United States actually began production on a large scale, producing in that year 87,500 pounds of magnesium. In 1940, however, this source of supply was exhausted, and the Dow Co. turned to Freeport, Texas, for a new plant to extract the metal from sea water. The process consists of pumping the sea water into the plant, part of which is used in the magnesium process and part in the extraction of bromine. Other methods of extracting the metal from ores found in the earth were described briefly, as well as new technique being investigated which will meet the tremendous war need for this metal.

With the Student Branches

University of Tennessee Host to Group IV Student Meeting, March 29–31

Fourteen Schools in Nine Southeastern States Represented

THE eleventh annual Southern Student Conference was held by the Group IV Student Branches on Sunday, Monday, and Tuesday, March 29, 30, and 31 at Knoxville, Tenn., with the University of Tennessee Branch as host. Registration headquarters in Ferris Hall, U. T. campus, opened Sunday afternoon for the early delegates and continued through Monday morning. An attendance of 169 student and faculty members was drawn from fourteen schools in nine Southeastern states.

Inspection trips were made on Monday morning to Gray-Knox Marble Company's quarry and mill, Knox Porcelain Corporation, and Sanford Day Iron Company.

Luncheon on Monday was a joint meeting with the Knoxville Technical Society at the Andrew Johnson Hotel with Richard F. Wagner, student member from Duke, presiding. Dean N. W. Dougherty, College of Engineering, University of Tennessee, gave an address on "Professional Recognition." Also, a tribute was paid to Dean Emeritus Charles E. Ferris who this year is completing a half century of teaching engineering at the University of Tennessee.

At the technical session held on Monday afternoon R. T. Staton, Jr., Mississippi State College, presided and five students presented papers.

Douglas, U. T. Chairman, Toastmaster

The banquet held on Monday evening was a joint affair with the East Tennessee Section of the A.S.M.E. F. Shelton Douglas, student chairman of the University of Tennessee

EVERY SUCCESSFUL CONFERENCE HAS ITS BANQUET

[Shelton Douglas, University of Tennessee Student Branch, presiding at the banquet on Monday night as R. P. Reece, representative of A.S.M.E. Committee on Relations with Colleges (left) and Dean S. B. Earle, vice-president of A.S.M.E. (right) lend attentive ears. Dean Earle was the principal speaker.]

1942 GROUP IV PRIZE WINNERS

[Front row, left to right: George Griffin, Vanderbilt (fourth prize, "Old Guard"); Jack Evans, chairman V.P.I. Student Branch, with attendance prize awarded to V.P.I. for having largest group at meeting; John E. Ginter, V.P.I. (first prize). Back row, left to right: E. A. Neu, Jr., Duke (second prize); D. E. Mapother, Louisville (fifth prize); L. F. Chandler, Tennessee (third prize).]

Branch, was toastmaster. Principal speaker was A.S.M.E. vice-president Dean S. B. Earle of Clemson College who took as his topic "The Engineer in War and Peace." An informal dance in the hotel ballroom followed the banquet.

The second technical session was held on Tuesday morning following a breakfast for Honorary Chairmen of the Branches and faculty members. Five students presented papers at this session presided over by Jack G. Evans, V.P.I. Student Branch chairman.

Awards Presented by R. P. Reece

The luncheon meeting on Tuesday at the Andrew Johnson Hotel was presided over by David Newbern, student member of the University of Louisville. An excellent technical paper on "Magnesium—Metal's Feather" was presented by W. Harry Vaughn of the Tennessee Valley Authority. The presentation of awards by R. P. Reece, representative of the National Committee on Relations with Colleges, was one of the high spots of the Conference.

The inspection trips on Tuesday afternoon to Cherokee Dam, Foreign and Domestic Veneer Company, and Southern Extract Company concluded the Conference.

Prizes Awarded

The technical sessions of the Conference held in Ferris Hall auditorium were excellent because of the interesting papers well presented and the lively discussions following the papers. The prizes were awarded as follows:

First prize, $50.00 to John E. Ginter, V.P.I., for his paper on "Practical Pin Method of Measuring Spur Gears."

Second prize, $30.00 to E. A. Neu, Jr., Duke, for his paper on "Designing an All-Purpose Projector."

Third prize, $15.00 to L. F. Chandler, Tennessee, for his paper on "Electrophotographic Ballistometry."

Fourth prize ("Old Guard"), $10.00 to George Griffin, Vanderbilt, for his paper on "Developments of the Coal-Dust Diesel."

Fifth prize, $5.00 to D. E. Mapother, Univ. of Louisville, for his paper on "Independent Suspension."

The attendance prize went to V.P.I. for having the largest visiting student group.

Students of Group X—Pacific Southwest Hold Eighth Annual Meeting

University of California Is Host

THE eighth annual Pacific Southwest Student Meeting, with the University of California as host, was held on March 27 and 28 at Berkeley, Calif. The conference was called to order by Joseph Gross of the University of Nevada who gave a short address and then introduced Prof. R. G. Folsom of the University of California who welcomed the students to the University. The judges of the excellence of the papers to be delivered were presented and immediately thereafter the serious business of the session started.

First Technical Session

Papers presented were by Carl Moyes of the University of California on "Nonmetallic Bearings," by Bernard J. Bannon of the University of Santa Clara on "Induction Heat Treating," by Gordon K. Woods of the California Institute of Technology on "A Direct-Reading Horsepower-Indicating Device," by James F. Nelson of the University of Southern California on "Metallurgy in the Oil Refinery." Following the presentation of each paper there was a five-minute period devoted to discussion and to questioning the author.

At the close of the first technical session discussion was opened on current student problems at the various schools. The main topic was of course the draft problem. At Nevada and Arizona the men were permitted to graduate and were given two months to obtain a defense job. If no such jobs were available, they were inducted into the Service. Men at Cal. Tech. and Southern California are generally placed in Class 2A or are in the Naval Reserve. Santa Clara and the University of California have changed to a three-semester year in order more quickly to prepare the undergraduates. Stanford seems to have a good arrangement—men are deferred until graduation if they maintain scholastic proficiency.

H. T. Avery, chairman of the San Francisco Section of the A.S.M.E., discussed postwar conditions and opportunities with those attending the conference, advising them to maintain their technical interests even at great sacrifice. The meeting was then adjourned.

Harvard Stewert Speaker at Dinner

The dinner was held in the Spanish room of the Hotel Claremont and at the session following, Bertil F. Peterson of the University of Santa Clara called the meeting to order, introducing Mr. Harvard Stewert of the Bethlehem Shipbuilding Corporation, whose talk on "The Demands of the Shipbuilding Industry" was heard with eager interest. Dancing closed the doings for the day.

The second technical session was called to order on Saturday morning by Carter Nelms of the University of Arizona. Papers were presented on "The Design and Calibration of a Thermal Anemometer," by Wesley H. Hillendahl, Stanford; "Aerodynamics of Sails," by John Blaich, University of Southern Calif.; "A Test of a New Design of a Rotary Gear Pump," by Lawrence W. Smith, California Institute of Technology; "Fire Extinguishing With High-Pressure Spray," by B. W. Depew, University of Santa Clara; "Cooling Towers, Their Uses and Problems," by Leslie M. Burgess, University of California.

After the presentation of papers Robert Rourke, of the University of California, announced the decision reached at the Honorary Chairmen's Breakfast that the meeting for 1943 would be held at the University of Southern California.

Prize Winners

After luncheon at the Hotel Durant, Dean G. L. Sullivan of the University of Santa Clara addressed the members on the subject of the engineer's future. Following a complimentary address by Dean McLaughlin of the University of California, Prof. R. L. Daugherty of the California Institute of Technology presented the prizes. First prize of fifty dollars went to Wesley H. Hillendahl of Stanford.

Lawrence W. Smith, California Institute of Technology, won the second prize, thirty dollars. The fifteen-dollar third prize went to Gordon K. Woods, also of Cal. Tech. B. W. Depew of the University of Santa Clara won the fourth or "Old Guard" prize of ten dollars. Fifth prize of five dollars went to Bernard J. Bannon of the University of Santa Clara.

Robert Rourke, University of California, summed up the feelings of all in his closing address when he said that the California members had completely enjoyed playing host and they hoped to be given the privilege again in the near future. The feeling of good-fellowship pervaded the entire conference. If the purpose of the conference was to bring various engineering schools in touch with each other then the conference met its purpose well and was highly efficient.

Prof. L. S. Marks Delivers Sigma Xi Lectures During April to Students

Fellow of A.S.M.E. Discusses Solar Energy, Windmills, Waterpower, Internal-Combustion Engines, and Turbines

THE main sources of power immediately and practically available in the world of today were discussed and appraised by Lionel S. Marks, Fellow A.S.M.E. and professor-emeritus of Harvard University, during the month of April in lectures given before mechanical-engineering students at Brooklyn Poly, West Virginia University, Washington University, University of Nebraska, University of Colorado, Louisiana State University, North Carolina State College, University of North Carolina, Miami University, University of Michigan, and Illinois Tech. Professor Marks spoke under the auspices of the Society of Sigma Xi, national fraternity for the promotion of scientific research.

Solar energy is the only important source of power, he stated. It is the cause of winds, of rain, and of plant growth. The solar energy of earlier ages is stored in coal, petroleum, and natural gas. Solar energy of recent times is stored in vegetable and animal matter, and in water above sea level.

Recent developments in power generation, which Professor Marks described, are a large power windmill, a more efficient water turbine, new alloys that withstand higher temperatures and thus permit higher steam temperatures, the mercury steam turbine, the high-compression airplane engine with its superchargers, and the gas turbine. The Diesel engine alone, he remarked, has shown no important improvement in thermal efficiency in the last thirty years. But it is still the most efficient small or medium-sized engine.

Branch Meetings

Student Papers at British Columbia

SOME of the student papers presented during February and March at meetings of BRITISH COLUMBIA BRANCH included "Scotch Marine Boilers," by P. H. Nasmyth, "Engineers and Public Affairs," by C. W. Nash, "Development of High-Speed Steels," by Edward Barton, "The Engineer's Part in the Development of Civilization," by Henry Curran, "A New Method of Fire Fighting," by George Carlyle, "Transfer Box of a 4 × 4 Army Truck," by Harold Lear, and "Erection of a Gin-Pole," by Walter Goodwin.

ARKANSAS BRANCH held its regular monthly meeting on Mar. 6. Three talks were presented by student members. A discussion was held as to which regional conference would be attended—the one in St. Louis, Mo., or in Houston, Tex. The latter was finally decided upon by a majority.

CALIFORNIA BRANCH members met on the evening of Mar. 18 and listened to Dick Belding describe his experiences as a football manager. The next part of the program consisted of motion pictures. The first, a technicolor presentation, showed the importance of the railroads in modern-day life, and the second was a review of the various phases of life in the "gay nineties."

CASE BRANCH made plans at the Mar. 11 session to hold a contest at which to choose a speaker to represent the Branch at the regional conference. The climax of the meeting was a skit put on by the seniors, imitating several faculty and student personalities on the campus. Prizes were given to the members for the best impersonations.

C.C.N.Y. Makes Inspection Trip

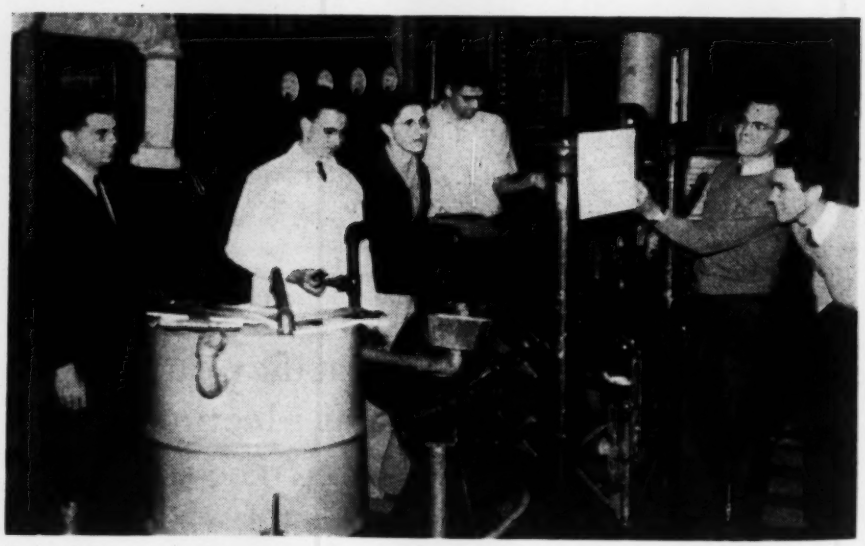
On Mar. 7, 33 members of C.C.N.Y. BRANCH made an inspection trip through the power plant of the Hotel New Yorker, New York City. The tour served to acquaint undergraduates with the operation of a large building's power plant, which consisted of steam-heating, electric-generation, air-conditioning, and ice-making equipment. This trip was one of the feature events of the year's program, inasmuch as all other sources for inspection trips are unavailable because of war restrictions.

On the evening of Mar. 27, the C.C.N.Y. BRANCH held a faculty-student smoker. Entertainment was furnished by a magician and a skit was put on by some of the most talented seniors. Refreshments were plentiful and the affair was declared a complete success.

COLORADO BRANCH joined with other engineering groups in accepting the invitation of the A.S.C.E. chapter on Mar. 2 to take part in a meeting at which motion pictures showing the failure of the Tacoma Bridge were exhibited.

Cornell Learns Bomb Protection

More than 60 members and guests of CORNELL BRANCH were present on Mar. 24 to hear Prof. Charles E. O'Rourke discuss the topic of "Bombs, Bomb Effects, and Bomb Protection." The paper was based on research work carried out by him. Some of the points covered by Professor O'Rourke included types of bombs, properties of high and low explosives, the bomb in flight, bomb effects such as impact and detonation or explosion, design problems created by bomb effects, analysis of building requirements, and separate shelters.



IN THE MECHANICAL LABORATORY OF THE UNIVERSITY OF FLORIDA

(A group of students prepares to run a test on 1941 Ford V-8 engine. This test was part of a much larger demonstration given in honor of Florida's Governor, Spessard L. Holland on his visit to the University of Florida on March 11. Included in the picture, left to right, are Prof. R. A. Thompson, honorary chairman of the A.S.M.E. Student Branch, and senior engineering students Clyde M. Mullis, Robert E. Morley, W. C. Van Clief, Allen A. Lang, and L. D. Hughes.)

A.S.M.E. STUDENT BRANCH MEETING AT THE UNIVERSITY OF KANSAS, FEBRUARY 9

DELAWARE BRANCH had as speaker at the Mar. 5 session, Miss Edith Solmans, American Viscose Company, who gave an illustrated talk on rayon. Because of the war, few, if any, plants were open for inspection, stated John Twilley. However, he reported that word had been received from the Edgemoor Iron Works that a small group would be admitted to the plant after Apr. 20.

FLORIDA BRANCH held a paper contest on Mar. 20 at which papers were presented by Frank Gagliardi on "Plastics—Uses and Limitations in the War Conservation Program," Robert Morley on "A Development in the Manufacture of Ice," and L. D. Hughes on "Photographic Method of Determining the Speed of Aircraft." Mr. Hughes won first honors and $5 in cash.

GEORGE WASHINGTON BRANCH also held a paper contest on Mar. 4. However, there were only two speakers, Julius Ritter and Sam Myers. The former won and will represent the Branch.

ILLINOIS TECH BRANCH held its contest for the selection of the best paper on Apr. 3. Speakers included Morris Horwitz, who discussed "Internal Stresses Due to Welding," and Hans J. Knapp, who described "Limiting Characteristics of Aircraft Performance." The latter member won.

IOWA BRANCH had some interesting student papers given during March. At the Mar. 4 session, John Keating talked on "Gas Turbines." At the Mar. 11 meeting, Frank Kenaley described "Military Tanks," and A. Lutz discussed "The Use of Plastics in Aeronautics."

President Parker at Kansas

Speaker and guest of honor at a luncheon held on Feb. 9 by KANSAS BRANCH was James W. Parker, president of the A.S.M.E. Following the luncheon, he gave a short talk on the opportunities available to engineers in industry.

KENTUCKY BRANCH announced at the Feb. 13 session that Paul Cohen, Harold W. Estill, and Jack Gaines have volunteered to prepare papers for presentation at the regional conference. Speaker at the Feb. 20 meeting was Paul D. Close, technical secretary of the Insulation Board, who spoke on "Building Insulation." Lloyd M. Potts, M.I.T., talked at the Feb. 27 session on problems in feedwater treatment, including scale, both chemical and colloidal, corrosion, foaming, priming, and caustic embrittlement.

M.I.T. BRANCH conducted a banquet on Mar. 18 which was attended by more than 60 members and guests. After an interesting talk by the guest speaker, Lieut. Comdr. Manning, the party was baffled by the prestidigitation of Professor Simpson, first vice-president of the Amateur Magicians' Society.

Section Guests at Michigan

Several executive-committee members of the Detroit Section were guests at the Mar. 25 meeting of the MICHIGAN BRANCH. A. M. Selvey, chairman of the Section, spoke on the advantages of student transfers to the parent society, and Ted Winkler gave a short talk on junior-group activities in the local sections. The second part of the program consisted of a student paper contest, which was won by Waldemar Rupinski for his paper on "The Mercury-Steam Cycle for Power Generation."

MISSISSIPPI STATE BRANCH members chose

A.S.M.E. STUDENT MEMBERS AT THE UNIVERSITY OF MICHIGAN, 1941–1942

THE SPEAKERS' TABLE AT THE DINNER OF A.S.M.E. NORTHEASTERN BRANCH, MARCH 17
(Left to right: Prof. A. J. Ferretti, Prof. A. E. Whittaker, Dean William G. White, Robert H. Murray, M. D. Engle, Prof. J. W. Zeller, and H. J. Brown.)

L. T. Wade, Jr., to represent the Branch at the regional conference. His subject will be "Aircraft Production," which is based on experience gained while in the employ of the Douglas Aircraft Corporation.

MISSOURI MINES BRANCH at its meeting of Apr. 1 selected the afternoon of Apr. 11 as the time for the annual spring outing. This discussion was followed with a talk by Charles Morris on the many reasons why every member should attend the regional conference.

NEBRASKA BRANCH held an interesting meeting on Mar. 4. Herman Schmall gave an illustrated paper on "Methods of Cooling Water," and W. N. Brown, chairman, discussed "Solid Injection with Spark Ignition." This was followed by the showing of a motion picture on "Ford Reconnaissance Cars."

Nevada Advocates Joint Meetings

As part of the meeting on Mar. 24, members of NEVADA BRANCH discussed a suggestion made by Prof. James Van Dyke concerning future meetings of the A.S.M.E. It was pointed out that owing to decreased membership in the Branch, as well as in other engineering groups on the campus, it was difficult to hold separate meetings. The possibility of each local group dispensing with individual meetings in favor of joint meetings was covered. The business of each organization would be carried out by executive committees.

NEWARK BRANCH's guest speaker on Mar. 17 was Dr. N. E. Woldman, chief metallurgical engineer of the Eclipse Aviation Corporation. His paper covered the problems confronting the young mechanical engineer in the science of metallurgy as applied to industry. He stated that to be a successful designer, one must be aggressive, self-confident, and possess ability.

NEW HAMPSHIRE BRANCH features student papers at most of its meetings. On Mar. 3, the speakers were C. E. Colby, J. Sleeper, and A. J. Touart. At the Feb. 17 session, William Clement spoke of the development of gas turbines, and J. H. Day covered the production and ballistics of the Springfield rifle.

NEW MEXICO BRANCH met a past "watermaster" on Mar. 10 when Dr. R. E Harrington spoke before the group. Among his many experiences, he held the position of watermaster at the Snake River Irrigation Project in Idaho. His job was to settle disputes which arose between landowners and the government.

N.Y.U. BRANCH (aeronautical) had as guest speaker at the Mar. 18 session, John Grant, Pan American Airways, who spoke on the development of the air line in South America.

N.Y.U. BRANCH (mechanical) held a speaking contest the evening of Mar. 19, at which the prize winners, as selected by Professors

ENJOYING THE ST. PATRICK'S DAY DINNER AT NORTHEASTERN

Church and Barrie, were Gerald Robinson, Martin P. Kurutz, and William Weschler.

Lawbreaking at Northeastern

High-lighting his talk on "Locks" with demonstrations of the various methods used by lawbreakers in licking locks, Alvin Steinberg was the student speaker at the Mar. 3 session of NORTHEASTERN BRANCH. It has been the policy of the branch that whenever an outside speaker is not available, a member takes over.

Over 80 members and guests attended the St. Patrick's Day banquet held on March 17 in the University Commons by Northeastern Branch. M. D. Engle, Mem. A.S.M.E., prominent in the power-plant field and assistant chief engineer for the Boston Edison Company, was guest speaker, taking for his subject "The recent Developments in Power Plant Installations." The lecture was illustrated with slides showing the many changes in boiler design over recent years and the change to high-pressure steam installation. Other guests were present from the Boston Section of the Society and from the faculty of Northeastern. Robert H. Murray, student chairman of the Branch, was toastmaster and introduced the speakers.

The first A.S.M.E. Student Branch Meeting of the spring quarter was held by student members at OHIO STATE on April 3. Dr. John E. Younger was the guest speaker at this meeting which was attended by 81 members and 4 guests. Dr. Younger, who is the head of the departments of mechanical and aeronautical engineering at the University of Maryland and secretary of the A.S.M.E. Aeronautic Division, delivered an exceedingly interesting talk in which he traced the history of the design of airplanes and gave an insight on the design of high-speed, high-altitude planes of the future. His lecture was accompanied by slides.

NORTHWESTERN BRANCH boasts that a new two-and-a-half story testing machine, which had its inaugural test on Mar. 12 in the technological laboratories of the University, can crush 18-in-thick concrete or gently crack egg shells. Capable of exerting a pressure of 1,000,000 pounds on a beam 55 feet long, it has the largest transverse testing capacity of any machine in the world. Despite its great power, it is capable of measuring loads to an accuracy of 1/10 of one per cent.

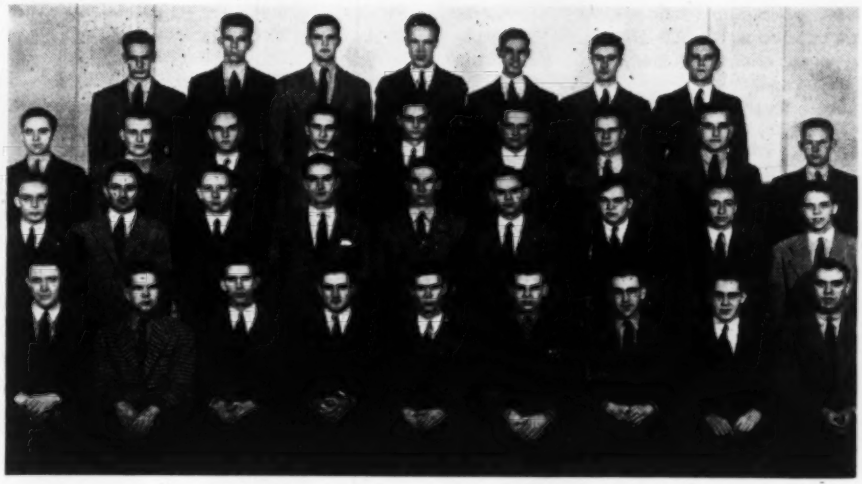
NOTRE DAME BRANCH reports that members of the St. Joseph Valley Section attended its meeting of Mar. 17 at which papers were offered by student members in competition for the honor of representing the Branch at the coming regional conference.

Ohio State Fine-Arts Show

The Feb. 27 meeting of OHIO STATE BRANCH was devoted to a display of fine-arts projects in Derby Hall. Dr. Hoyt L. Sherman, of the fine-arts department, opened the discussion with a short talk concerning the purpose of the exhibit and then answered questions propounded by some of the 83 student members who were present. The meeting was closed with the serving of refreshments.

PENN STATE BRANCH featured two motion pictures at its Mar. 9 meeting. One covered

AT THE "PIEFEST" ON FEB. 2 OF A.S.M.E. STUDENT BRANCH AT PURDUE



A.S.M.E. STUDENT BRANCH MEMBERS AT RENSSELAER, 1941–1942

the history of aluminum and the methods of obtaining it, the other discussed safe driving and showed the methods of obtaining the most economical use from present-day automobiles.

PITTSBURGH BRANCH had a record audience of more than 250 members and guests at the Feb. 26 session. The program consisted of a motion picture produced by the U. S. Bureau of Mines in conjunction with the Westinghouse Elec. & Mfg. Co., and entitled "Mining Coal in the Electrified Wildwood Mine."

Purdue Meets With Section

Another highly successful joint dinner was held by PURDUE BRANCH and the Central Indiana Section of the A.S.M.E. on Mar. 13. Papers were presented by three student members from PURDUE and one from ROSE POLY BRANCH. G. F. Topinka spoke on "Wing Vibration and Flutter," W. L. Clearwaters on "A New High-Speed Pressure Pickup," W. J. Gaugh on "A Locomotive Speedometer for Fuel Economy," and Allen Ker (Rose Poly) on "Bulldozer Design." On Feb. 24, diverging from the custom of holding every meeting open to the public, a closed "Piefest" for members only was held. Dr. G. A. Hawkins, of the heat-transfer department, showed some interesting movies. There was so much pie that everyone had more than his fill. At the Mar. 3 session, "Combustion Gas Turbines" were discussed by J. T. Rettaliata, junior A.S.M.E., and authority on the subject.

QUEENS BRANCH met on Feb. 26 and showed several motion pictures to the audience of 50. The first of the films, "Hydraulics," dealt with the application of the hydraulic transmission of power to automotive brakes, and to the actuation of bomb racks, landing gear, and ailerons of airplanes. The second, "Airscrew," showed the manufacture and testing of airplane propellers and the construction and operation of variable-pitch propellers. Finally, "Power for Defense" illustrated the new electrical power developments and their application to war production in textile mills, aluminum-sheet rolling mills, electrolytic production of essential metals, and shipbuilding.

R.P.I. Meeting Attracts 300

More than 300 members and guests of R.P.I. BRANCH came to the Feb. 17 session to hear Bruce Crane, Ethyl Corporation, discuss gasoline research, development of the octane number, and the operation of internal-combustion engines. He then showed a sound motion picture which demonstrated the method of photographing the moving wave front of burning fuel in the cylinder of an engine. The talk was concluded with a demonstration of the operation of an internal-combustion engine. The large audience was due to the fact that the day before members had passed out handbills which read as follows: "Wastin' Gas? Does the old jallopy pound and wheeze? See real engines in operation. Watch them kick over on poor and good gas. See how to give the old bus new speed and power! For the last-minute dope on gas and engines, join the gang at the A.S.M.E. meeting, Feb. 17, Sage Lab."

RICE BRANCH devoted its meeting of Mar. 20 to the presentation of papers by two student members. W. M. Koch presented a paper on the economy of an automotive engine. L. L. Blake gave a talk on metal spraying.

S.M.U. BRANCH members were guests of the North Texas Section on Mar. 16 at which students presented papers in competition for prizes donated by the Section. First prize was won by M. B. McDonald with a paper on "Recent Developments in the Two-Stroke Engine," second prize was awarded to G. W. Beesley for his talk on "Engineers in Preparing for the Coming Peace," and third prize to R. P. Dill, Jr., for "Tooling Up: Drill Jig for Aluminum Plate."

STANFORD BRANCH held a meeting on Mar. 4 to see two films, "The Construction of Boulder Dam" and "The Making of a V-Engine." Cider and doughnuts were served.

Texas A.&M. Welcomes Ernest Hartford

Guest speaker at the Mar. 19 meeting of TEXAS A.&M. BRANCH was Ernest Hartford, executive assistant secretary of the A.S.M.E. He spoke on the Society as a whole, pointing out the various branches embraced by mechanical engineering in industry. Following the talk, a short film, "Look to Lockheed for Leadership," was shown.

TEXAS BRANCH, it was reported at the Mar. 16 meeting, is doing its part for the armed forces by collecting books and magazines for them. Speakers at this session included Vaughan Connor, "The University of Texas Quick-Freezing Machine," and John E. Kunz, "Texas Lignite—The Neglected Fuel of National Defense." On Mar. 14, the Branch held a "Ranch Party," which was well attended by members and their guests.

TEXAS TECH BRANCH had the three members selected to compete at the regional conference give their papers before the group at both the Mar. 3 and 16 meetings. The speakers were John P. Mooney, J. B. McEwin, and Wesley Powell.

MECHANICAL ENGINEERING SENIORS AT THE UNIVERSITY OF UTAH

(Left to right: *Front row*, C. A. Bergman, G. E. Kaattari, Bengoechea, W. R. Mathews, Elden Austin; *second row*, E. B. Wilson, R. O. Vance; *third row*, W. J. Middlemiss, F. L. Bagby, Jr., K. V. Smith, C. G. Manning, D. A. Olson; *fourth row*, C. G. Parker, W. R. Gould, L. G. Bywater, C. R. Lesser; *fifth row*, H. E. Orton, Gardner, T. L. Hicken, Erickson.)

For Account of Group VII Meeting, See Page 412

THE Student Meeting of Group VII, Southwest, was held in conjunction with the Spring Meeting of the Society at Houston, Texas, and is included with the general account. A photograph of the prize winners of Group VII will also be found on page 412.

Tufts Discusses Engineering and Women

The first annual banquet of TUFTS BRANCH was held on Feb. 27. It was proclaimed a success by all 82 attending. After a sumptuous meal, Peter H. Morganson, chairman of the Branch, introduced the evening's speakers, Kerr Atkinson, Jackson & Moreland Co., and Prof. F. Alexander Magoun, M.I.T. Mr. Atkinson's topic was the "Practice of Engineering" and concerned itself with his personal experiences in that field. Professor Magoun spoke on "What You Saw in Her," a discussion of the factors that make and break marriages.

VERMONT BRANCH devoted its meetings in February and March to making plans for the forthcoming regional conference, Apr. 24–25, at which it would be the host branch.

VILLANOVA BRANCH on Mar. 9 held a meeting of the chairmen of the various committees formed to make plans for the regional conference. It was announced that difficulty was being encountered in arranging for inspection trips because of wartime restrictions. At the Mar. 23 session, it was decided to dispense with the trips and substitute for them some motion pictures of unusual industrial operations.

Washington Steam Men's Strut

A dance, dubbed "Steam Men's Strut," was held by WASHINGTON UNIVERSITY BRANCH on Mar. 17 in the mechanical laboratory among all the machines and equipment. The Corliss steam engine was kept running with electric-light bulbs attached to the flywheel. The men came in "engineers' formal," their overalls. Besides dancing, there were games, entertainment, and a plentiful supply of food and soda.

WORCESTER BRANCH turned its meeting of Mar. 25 over to the U. S. Navy. Capt. Charles L. Brand, industrial manager of the Boston Navy Yard, spoke on the subject of "Engineering in the Navy," in which he covered the different kinds of work being performed by engineers. The photograph of the officers of this Branch is published on this page.

YALE BRANCH continued it program of student papers at the Mar. 10 meeting. The speakers included H. B. Gerling, "Balls for Ball Bearings;" W. J. McAndrews, "The Chicago Subway;" W. E. Coykendall, "Tapping;" W. A. Devine, "Trend of Increase in the Production of 75-Mm Cartridge Cases;" and J. J. Keating, "Can America Win the War?" The last speaker won the applause of the audience when he answered his question in the affirmative.

Carl Moneymaker, Jr., Senior at University of Missouri, Dies

CARL MONEYMAKER

CARL Moneymaker, Jr., senior in the mechanical-engineering department at the University of Missouri, met an untimely death in an automobile accident near Columbia, Missouri, on January 10, 1942. Mr. Moneymaker was born near Mt. Leonard, Missouri, August 16, 1917. The family soon moved to Kansas City, Mo., where he attended elementary school and Paseo High School in Kansas City, engaging in such activities as the Safety Patrol Squadron and the Stamp Club. He was always very popular and was the leader of his group in the Blue Valley District of Kansas City. His mechanical interest and skill soon became manifest. He once took parts from a Ford, Chevrolet, and Studebaker and built a midget racer from them. He was much interested in internal-combustion engines and hoped to build racing cars after graduation. He had completed plans for a racing engine, but had not begun on the actual construction at the time of his death. At the University of Missouri he earned all of his expenses by delivering *The Columbia Daily Tribune*, Columbia newspaper, to the surrounding towns.

Attesting their admiration and esteem for Carl, the senior class of mechanical-engineering students at the University of Missouri have presented a petition to the Policy Committee of the University asking that Carl be awarded a diploma posthumously and that his name be recorded with those of the graduating class of 1942.

Carl Moneymaker, Jr., will long live in the memory of the many friends that he made at the University of Missouri.

On January 1, 1942, just ten days before his accident, Mr. Moneymaker was married to Miss Lucille Walters.

1941–1942 OFFICERS OF A.S.M.E. STUDENT BRANCH AT WORCESTER POLYTECHNIC INSTITUTE
(Left to right: Ralph G. Fritch, secretary; Felix A. Thiel, Jr., vice-president; Peter P. Holz, president; Elton J. Sceggel, treasurer.)

Winner of 1931 A.S.M.E. Student Award Writes for Argentine Society

THE American Society of Mechanical Engineers has recently received from the Argentine Institute of Applied Electricity a copy of a monograph, in the Spanish language, entitled "Technical and Economic Bases for the Selection of Air-Conditioning Installations," by Jules Podnossoff.

Mr. Podnossoff is a Junior member of the A.S.M.E. who is now living in Buenos Aires as a representative of the General Electric Company. He is a graduate of the Polytechnic Institute of Brooklyn and has already received two awards from the A.S.M.E. In 1930 he won the Charles T. Main Award for his paper, "The Value of the Safety Movement in the Industries," which was published in the A.S.M.E. Transactions. The following year he received the Student Award for a paper, "Pressure and Energy Distribution in Multistage Steam Turbines Operating Under Varying Conditions."

1942 List of American Standards Available

THE American Standards Association has announced the publication of its new list of American Standards for 1942.

Nearly 500 American Standards are listed in a wide variety of industrial fields and in the fields of industrial and public safety. There is a separate heading for American Defense Emergency Standards—standards which have been developed specifically for defense purposes, and for the the first time all American Safety Standards are listed together in a separate section.

These standards include definitions of technical terms, specifications for metals and other materials, methods of test for the finished product, dimensions, safety provisions for the use of machinery, and methods of work. They reach into every important engineering field, serving as a basis for many municipal, state, and federal regulations.

In each case these standards represent general agreement on the part of maker, seller, and user groups as to the best current industrial

practice. More than 600 organizations are taking part in this work. The standards are frequently reviewed and revised in order to keep them in line with changing industrial needs. New standards, and those brought up to date within the year, are especially marked in the list.

This list of American Standards for 1942 will be sent free of charge to anyone writing in for it. Requests should be addressed to the American Standards Association, 29 West 39th Street, New York, N. Y.

Franklin Medal Awarded to J. C. Hunsaker

THE highest honor that it is in the power of The Franklin Institute to bestow was awarded to Dr. Jerome Clarke Hunsaker, former vice-president A.S.M.E., at the annual Medal Day exercises of the Institute on Wednesday, April 15. He was presented with the Franklin Medal and a certificate of honorary membership, "in recognition of his pioneer work in education in the field of aeronautical science, and of his many invaluable contributions to that science."

Dr. Hunsaker is chairman of the National Advisory Committee for Aeronautics. A graduate of the Naval Academy, he very early became identified with aeronautical research and design, and his studies here and abroad culminated in such achievements as the establishment of the first courses in aerodynamics in the country, the building of the first wind tunnel, and other technical advances. He designed the NC type of flying boat, one of which made the first successful transatlantic flight in 1919, and also the Shenandoah, the first large airship to be built in this country.

Tobey to Head Coal Bureau of Upper Monongahela Valley Association

EFFECTIVE April 15, Julian E. Tobey, formerly vice-president of Appalachian Coals, Inc., of Cincinnati, became managing director of the newly organized Coal Bureau of the Upper Monongahela Valley Association, with headquarters at Fairmont, W. Va.

The new Coal Bureau was formed by coal-industry leaders in ten West Virginia counties and the Upper Monongahela Valley Association to exploit the vast reserves of high-volatile low-fusion coals in the area, whose basic fuel value is not generally appreciated. The bureau plans, through an engineering advisory service, to bring about an understanding of the economic possibilities of Pittsburgh seam coal, through the installation of modern combustion equipment.

Tobey, in 1934, was selected to organize and head the Fuel Engineering Division of ACI, because of his knowledge of fuels, utilization, and consumers' problems. Thousands of retail coal men have benefited from the stoker schools, coal exhibitions, lectures, fuel surveys, and educational literature prepared under Tobey's direction.

Active as a member of several national engineering societies, Mr. Tobey is vice-chairman, Ohio State Board of Registration for Professional Engineers and Surveyors, director of engineering for the Coal Producers Committee for Smoke Abatement, chairman of the Technical Advisory Board and Technical Executive Committee of Bituminous Coal Research, Inc., and a member of the Executive Committee, Fuels Division, A.S.M.E.

H. L. Guy Made Secretary of The Institution of Mechanical Engineers

ON March 16, Henry Lewis Guy, F.R.S., assumed secretaryship of The Institution of Mechanical Engineers (Great Britain). J. E. Montgomery, who has served as secretary since

H. L. GUY

the retirement of General Mowat, will continue on the staff of the Institution.

At the annual general meeting on Feb. 20, 1942, of The Institution of Mechanical Engineers it was announced that Col. S. S. Thompson had been elected president and Eng. Vice-Admiral Sir George Preece K. C. B., and Harry R. Ricardo had been elected vice-presidents.

Hart Cooke Given Fiftieth Anniversary Dinner

ON February 28, at the Osborne Hotel, Auburn, N. Y., Harte Cooke, vice-president of The American Society of Mechanical Engineers, 1937–1939, was guest at a dinner given in his honor to commemorate completion of 50 years of service with the McIntosh and Seymour Corp. and its successor, the Diesel Division of the American Locomotive Company, of which Mr. Cooke is senior engineer.

Stepanoff Paper Wins Hydraulic Prize

A COPY of a paper, "Design of Mixed-Flow Impellers for Centrifugal Pumps," by A. J. Stepanoff, member A.S.M.E. and Melville Medalist in 1932. The paper was awarded first prize in 1941 by the Hydraulic Institute. The Society's copy of Mr. Stepanoff's paper has been placed on file in the Engineering Societies Library, New York, N. Y., where it is available for reference.

Robert B. Rice Is Named Secretary N. C. Society of Engineers

PROF. Robert B. Rice, chairman of the A.S.M.E. Raleigh Section, head of the department of experimental engineering and director of the Naval Training Program at North Carolina State College, Raleigh, N. C., has been elected secretary of the North Carolina Society of Engineers to succeed Roy L. Williamson.

Supplement to

Test Code for Hydraulic Turbines

THE revision of the A.S.M.E. Power Test Code for Hydraulic Turbines, published in 1938, omitted standard methods for measuring water by the following five methods: (1) two-type current meter, (2) pitot tube, (3) pitometer, (4) traveling screen, and (5) photoflow. However, Power Test Code Committee No. 18 has continued its investigations on these methods of measurement through the activity of special subcommittees.

It is now possible to announce the completion and publication of the report on one of these methods, namely, the Cole Pitometer Method. Copies of this four-page pamphlet may be obtained upon application to the A.S.M.E. Publication Sales Department, 29 West 39th Street, New York, N.Y. There will be a charge of twenty cents a copy.

This supplement to the Power Test Code for Hydraulic Turbines contains also an amendment to Par. 147 of the code in the form of an improved basis for the determination of the pitot-tube coefficient.

Specifications for Mineral Wool in Low-Temperature Installations

AFTER formulation by its technical committee and approval by the engineering staffs of the principal mineral-wool-insulation manufacturers, the Industrial Mineral Wool Institute has adopted and released Specification No. 1—"Mineral Wool in Low Temperature Installations."

This is an eight-page, $8\frac{1}{2} \times 11$-in. book covering material specifications, specifications for surface preparation of areas to be insulated, in addition to individual specifications for the application of mineral-wool insulation on walls, floors, ceilings, piping, and fittings. Twelve engineering-drawings in perspective illustrate approved methods of applying mineral-wool insulation, providing the neces-

sary vapor barriers, supporting and finishing off the insulation in various applications.

Copies may be secured without charge by writing to Richard L. Davis, secretary, Industrial Mineral Wool Institute, 441 Lexington Avenue, New York, N. Y.

Abstract Service, Synthetic Resins, Rubbers, Plastics

A LOOSE-LEAF abstract service, treating the complete field of synthetic resins, rubbers, and plastics, has been inaugurated by Interscience Publishers, Inc., 215 Fourth Ave., New York, N. Y., edited by H. Mark and E. S. Proskauer. The first issue, 33 pages, contains the table of contents and a number of abstracts of the January issues of scientific and technical periodicals. The service is to be issued 12 times a year, at a subscription price of $35 a year, which is expected to cover from 500 to 600 pages.

Grease and Oil Guide for Antifriction Bearings

THE Annular Bearing Engineers' Committee, composed of the chief engineers of antifriction-bearing manufacturers, has recently adopted a "Guide for the Selection of Lubricants for Ball Bearings." The guide is issued in mimeograph form by the Committee, H. O. Smith, secretary, Room 2825, 60 East 42nd St., New York, N. Y. It covers grease and oil lubrication.

Oil-Burner Standard Issued

THE National Bureau of Standards, Division of Trade Standards, Washington, D. C., has recently issued Commercial Standard CS75–42, "Automatic Mechanical-Draft Oil Burners Designed for Domestic Installations (Second Edition)" in mimeograph form.

A.A.A.S. Summer Meeting Is Canceled

THE American Association for the Advancement of Science has announced the cancelation of its 1942 summer meeting which was to have been held at Ann Arbor, June 22–27.

S.P.E.E. Annual Meeting Changed to June 27–29

THE Society for the Promotion of Engineering Education announces that the dates of its 1942 Annual Meeting have been changed to Saturday, Sunday, and Monday, June 27, 28, and 29. The meeting will be held in New York, with sessions at Columbia University. The hosts for the meeting will be Polytechnic Institute of Brooklyn, Cooper Union, Manhattan College, New York University, College of the City of New York, Newark College of Engineering, Pratt Institute, Princeton University, Rutgers University, Stevens Institute of Technology, Webb Institute of Naval Architecture, and the S.P.E.E. Middle Atlantic Section.

A.M.A. "Production for Victory Conference," New York, May 13-14

THE American Management Association has requested that attention of A.S.M.E. members be directed to its "Production for Victory Conference," to be held at the Hotel Astor, New York, N. Y., on May 13 and 14.

Some of the topics mentioned in the preliminary announcement of the Conference are: Better organization for war production. What's being done to stimulate worker enthusiasm? What have W.P.B. production drives accomplished? Women workers' induction training. Getting the most life out of equipment. Production control.

A.S.T.E. Elects Officers

AT the tenth annual meeting of the American Society of Tool Engineers, held in St. Louis, March 26–28, Otto W. Winter, vice-president in charge of manufacturing, Republic Drill and Tool Co., Chicago, Ill., was elected president. Vice-presidents elected were Ray H. Morris, vice-president, Hardinge Brothers, Inc., and Douglas D. Burnside, superintendent, St. Louis Stove Co. Frank R. Crone and Clyde L. Hause were re-elected treasurer and secretary, respectively.

To fill the post of executive secretary left vacant by the death in 1941 of Ford R. Lamb, the directors selected Adrian L. Potter, formerly manager of the Convention Bureau of Springfield, Mass.

Naval Aviation Volunteer Service Wants Engineers

IT has been learned from reliable and confidential sources that no more applications are being taken for the Engineering Volunteer Service (E-V(S)) of the United States Navy. However, it has also been learned that 250 mechanical engineers are needed in the Aviation Volunteer Service (A-V(S)). These men will be chosen through the Naval Aviation Cadet Selection Boards throughout the United States, which are located in the various Naval Districts.

Mechanical engineers residing within the states of New York, Connecticut, and northern New Jersey may apply by mail, telephone, or in person at Room 1653, 120 Broadway, New York, N. Y.

General qualifications include submission of transcripts of birth certificate and college record or equivalent engineering experience. Applicants must be between the ages of 19 and 50, citizens of the United States of at least ten years' standing, and in good physical condition. Color-blindness does not disqualify in this division if the applicant has an engineering degree.

A.S.M.E. Local Sections

Coming Meetings

Buffalo. May 19. Markeen Hotel, Buffalo, N. Y. This is the Annual Jamboree. Pictures will be shown of Amphibian Co.'s "Aqua Chetah."

Central Indiana. May 8, 1942. Indianapolis Athletic Club, Indianapolis at 6:30 p.m. Subject: "Symposium on Plant Expansion."

Detroit. May 5. Horace H. Rackham Memorial Building, Detroit, Mich., at 8:00 p.m. Subjects: "The A.S.M.E. in National Affairs," by James W. Parker, president, A.S.M.E.; "A Military Engineer Reviews the World Crisis," by Colonel Henry W. Miller, University of Michigan.

Ithaca. May 8. Cornell University, Ithaca, N. Y. This will be an evening meeting. Subject: "A.S.M.E. Faces a Fork in the Road," by James W. Parker, President of A.S.M.E.

Metropolitan. May 1. Hotel Astor, Times Square, New York, N. Y. Fourth Annual Spring Round-Up Dinner, 7:30 p.m. Business dress. Movies, entertainment, and dancing.

New Haven. May 23. New Haven Country Club, New Haven, Conn. This is to be the Spring Meeting of the Connecticut Sections, and will be of a social nature with sports and entertainment in the afternoon followed by a dinner at which President James W. Parker will deliver an address.

Philadelphia. May 26. Cedarbrook Country Club, Glenside, Pa., at 6:30 p.m. Annual meeting, dinner and dance.

Pittsburgh. May 1. All-Day Meeting at Hotel Roosevelt, Pittsburgh, Pa. War Technology and Civilian Defense Sessions start at 9:30 a.m. For speakers and subjects see page 407 of this issue.

West Virginia. May 15. The Daniel Boone Hotel, Charleston, W. Va., at 8:00 p.m. The speaker of the evening will be L. E. Whitmoyer, sales technical adviser, Finish Division, E. I. du Pont de Nemours & Co., Philadelphia, on the subject "Maintenance Painting in Industrial Chemical Plants."

Massachusetts Registration Board Organizes

THE Board of Registration of Professional Engineers and of Land Surveyors for the Commonwealth of Massachusetts, created by an act of the legislature on October 9, 1941, has been organized and is now receiving applications for registration. Forms may be obtained from the Division of Registration, 413 State House, Boston, Mass.

The Board consists of Messrs. Ralph F. Gow, member A.S.M.E. (mechanical engineering), chairman; Gustavus J. Esselen (chemical engineering), vice chairman; Holcombe J. Brown, member A.S.M.E. (mining and metallurgy); Karl B. McEachron (electrical engineering) and Albert Haertlein (civil engineering), secretary.

(*A.S.M.E. News continued on page 428*)

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